MAG Fixed Guideway System Study

Final Report

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E.0 Executive Summary

E.1 Introduction and Conclusions

The Maricopa Association of Governments (MAG) Fixed Guideway System Study was undertaken as part of the Valley Connections project as a cooperative effort between MAG and the cities of Phoenix, Tempe, Scottsdale, Glendale, and Mesa. The study analyzed fixed guideway system options for the Phoenix metropolitan area, including the evaluation of alternative corridors and transit technologies. Technologies assessed include express bus/busway, light rail transit (LRT), commuter rail and automated rail.

A fixed guideway and express bus concept with improved local bus service is recommended for further study. An expansion of local bus service is recommended to ensure transit coverage throughout the region and to meet the needs of the transit dependent. Express bus service is recommended to meet the needs of commuters in outlying areas and to facilitate reductions in congestion. A Light Rail Transit (LRT) system is recommended to provide capacity and improve the quality of transit service in central high demand corridors. LRT serves central activity centers, and supports economic development and land use relations within these areas. Shuttle service is included to expand the service area of LRT and express buses in core areas.

A funding scenario was developed to demonstrate the magnitude and feasibility of the recommended transit concept. Each option has been modeled to demonstrate the relative performance of options. However, because this is a system level analysis, cost and ridership figures need to be analyzed in more detail at the corridor and program level. Also, due to updates to the MAG travel demand model, ridership results are viewed as preliminary. It is recommended that this study serve as one of several inputs to a more detailed study to update the transit element of the MAG Long Range Transportation Plan.

The MAG Fixed Guideway System Plan effort is one of three studies which have been undertaken to address high capacity travel demand and mobility needs in the Phoenix metropolitan area. The studies consist of:

- MAG Fixed Guideway System Study
- Central Phoenix East Valley Major Investment Study (MIS)
- Glendale/North Phoenix Major Investment Study (MIS)

In addition, MAG and ADOT have initiated the Grand Avenue MIS which will address highway and transit improvements in the Grand Avenue corridor. An adopted section in the Central Phoenix/East Valley Corridor has proceeded to preliminary engineering and an environmental analysis.

E.2 Study Process

This study was completed by BRW, Inc. in cooperation with MAG staff. The MAG Regional Council has confirmed that oversight should be jointly provided by the MAG Transportation

Review Committee (TRC), the Regional Public Transportation Authority (RPTA) Team, and Valley Metro Operations Staff (VMOS).

The study process included the following seven tasks:

- Task 1.0: Revised Scope of Work
- Task 2.0: Identify High Demand Transit Corridors
- Task 3.0: Review Previous Studies
- Task 4.0: Develop Fixed Guideway System Concept Options
- Task 5.0: Analyze Principal Alternatives
- Task 6.0: Detail Preferred Alternatives
- Task 7.0: Final Report

These results of these tasks are documented in the chapters of this report.

On January 22, 1997 the MAG Regional Council approved a fixed guideway starter corridor for inclusion in the draft FY 1997 update of the MAG Long Range Transportation Plan for Conformity Analysis. This analysis has been completed and the plan was approved in September 1997. The corridor extends along Central Avenue in Phoenix, and then extends east from downtown Phoenix to downtown Tempe and into Mesa. The RPTA Board of Directors endorsed the MIS results for this corridor in May, 1998, which includes light rail transit and supporting bus operations. Congress has approved $9 million for an environmental impact statement and preliminary engineering for this corridor. The City Councils of Phoenix, Tempe and Mesa approved local funding match for continuing LRT studies in September, 1998.

E.3 Overview of Previous Studies

A number of previous studies have examined fixed guideway transit systems for the Phoenix metropolitan area. The key fixed guideway planning studies that have been completed in the past include:

- Transit Systems Planning Study (1988)
- MAG Regional Transportation Plan Fixed Guideway System Study (1993)
- Arizona Rail Passenger Feasibility Continuation Study (1993)
- Phoenix Transit Plan - Camelback to CBD Corridor (1990)
- Phoenix Downtown Rail Trolley Feasibility Study (1995)
- Commuter Rail Demonstration Project (1994)
- Phoenix-Mesa Commuter Rail Study (1980)
- Tempe Circulation Study (1993)

These previous transit system planning efforts have identified several high travel demand transit corridors in the region. The *Transit Systems Planning Study* was the most comprehensive system planning effort, and provides a framework for the current planning effort. The findings of each individual study contribute to the definition of the purpose and need for a well-defined regional transit system.

E.4 High Demand Transit Corridors

Fixed guideway transit plays its most important role in heavily traveled corridors where large numbers of trips between similar origins and destinations are made. The highest volume corridors will generally have the greatest congestion problems and the most need for additional transportation capacity.

The first step in the evaluation procedure involved analyzing the projected 2020 travel patterns and projected roadway network conditions utilizing the MAG Regional Travel Demand Model. (Note: The MAG model is in the process of being updated.) A screenline analysis was conducted by corridor segment for the purpose of identifying travel volumes, corridor capacity and resulting levels of congestion. Corridor segments were then ranked based upon magnitude of travel demand and congestion. Subsequent considerations were then utilized to define a set of regional travel corridors for further evaluation as fixed guideway corridors.

Figure E-1 displays the identified high demand transit corridors. Key considerations included corridor travel demands and level of congestion and under-served demand. Previously studied transit corridors and the need to provide for continuity and connectivity between high demand transit corridor were also key considerations.

E.5 Transit Technologies and Fixed Guideway System Options

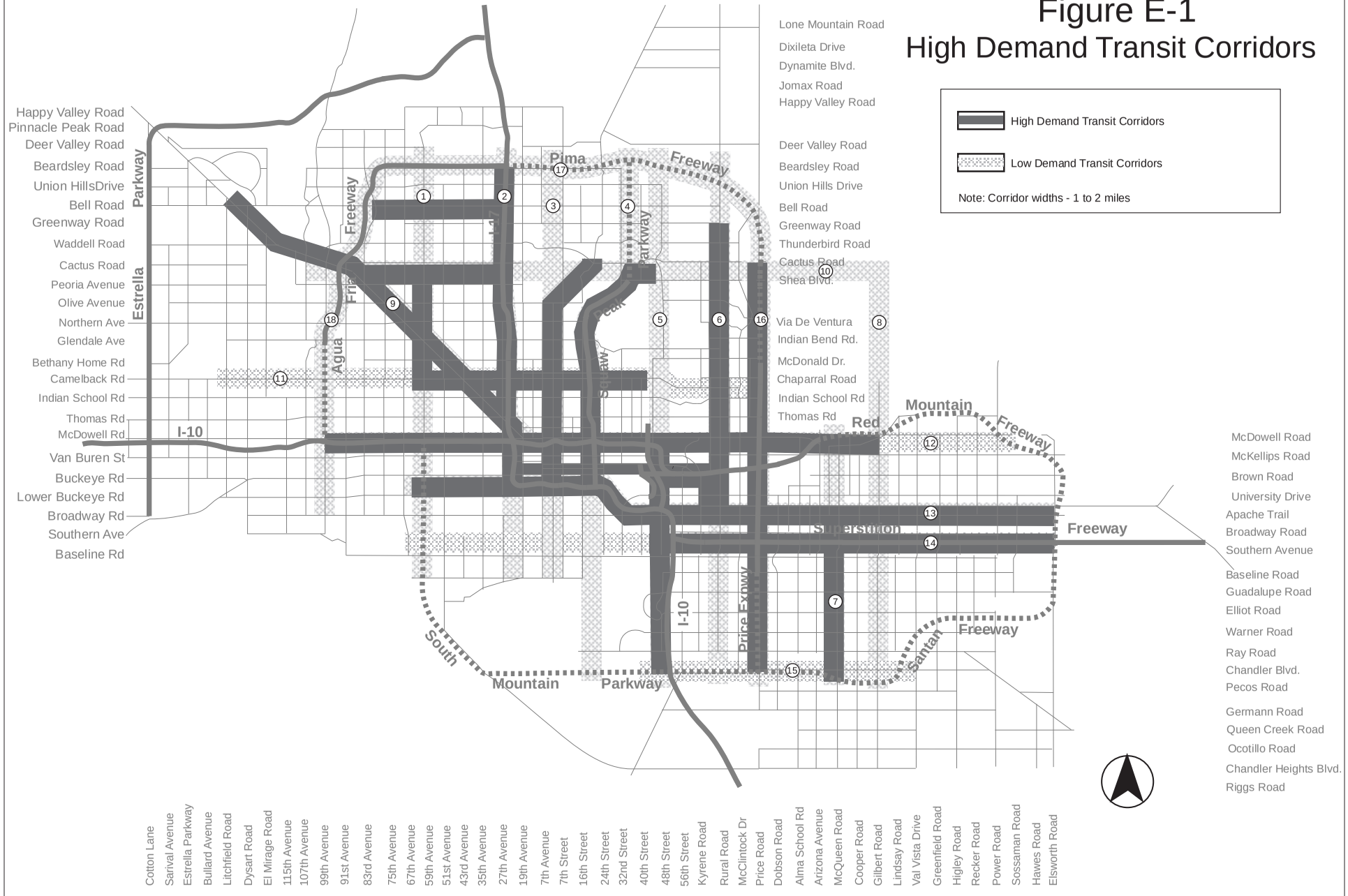
A set of fixed guideway system options were identified and modeled based upon previously identified high demand travel corridors and feasible transit technologies including:

- Express Bus
- Commuter Rail
- Light Rail
- Automated (Grade-separated) Rail

The Fixed Guideway System options that were analyzed included:

- Existing MAG Long Range Plan – The current plan provided a basis for comparing the costs, performance, and cost-effectiveness of the Fixed Guideway Transit System options. The plan focuses on region wide improvements in bus service. With this option, bus service is doubled and then increased an additional 36% for growth.
- Express Bus/Busway – This option addresses the needs of peak period commuters by focusing service on collecting passengers in outlying areas and providing

Figure E-1
High Demand Transit Corridors



express access to activity centers. The option includes a five-fold increase in revenue miles of express bus service above planned conditions. This option also includes 22 new on-line freeway bus stations, numerous new park-and-ride lots, 48 lane miles of new HOV lanes and upgrading of Grand Avenue to a grade-separated expressway and busway concept with HOV lanes and bus stations every mile.

- Commuter Rail – This option provides peak period commuter rail service on all major rail links in the Valley and would serve longer distance trips by suburban commuters who work in central areas. Because stops are further apart, transfers between the commuter rail and local bus are required in central areas, while auto and local bus access is needed in outlying areas.
- Light Rail – This option includes a 68-mile at-grade light rail transit system. The option includes 12 miles of support circulation routes, with reconfiguration of local bus services to support light rail stations.
- Automated Rail – This option includes 31 miles of fully grade-separated light rail. In a similar manner to light rail, bus routes have been reconfigured to serve stations and downtown circulators have been included to facilitate access in central areas.
- Light Rail Plus Commuter Rail – This option combines the Light Rail and Commuter Rail options with commuter rail service in the Union Pacific Corridor and Light Rail serving more centralized areas. Local bus, express bus and circulator bus services were also adjusted to avoid duplication and serve rail stations.
- Light Rail Plus Express Bus – This option combines limited light rail service from the Light Rail option, along with expanded express bus service. Light rail lines were terminated at major park-and-ride lots just beyond activity centers. Express bus service would be provided during the peak period in the peak travel direction.

E.6 Evaluation of Fixed Guideway System Options

Each of the Fixed Guideway System Options were modeled using the MAG Regional Travel Demand Model to derive transit ridership and performance data for the year 2020. (Note: specific model information could change as the model is updated.) Where appropriate, local and express bus routes were modified to feed fixed guideway station locations and, in some cases, eliminated if determined to be providing redundant service. Annualized estimates of both capital and operation and maintenance costs were also developed for each system option for the year 2020. The service, performance and cost data provided the basis for comparison of each of the system options with the existing MAG Long Range Transportation Plan.

Specific evaluation criteria were developed and applied as performance indicators of how well a particular system option would achieve specific regional mobility, environmental, social/economic, and financial goals and objectives. The cost-effectiveness of the alternatives was also evaluated by applying the cost of the alternative (annualized capital, operation, and maintenance) per unit of performance, such as transit boardings or reduction in highway

congestion. Factors related to land use and service to underserved population were also considered.

The following goals were approved by the MAG Transportation Review Committee (TRC) and RPTA for use in this study:

- Goal 1: Improve Regional Mobility
- Goal 2: Minimize Impacts On the Environment
- Goal 3: Support Community Social and Economic Goals
- Goal 4: Maximize Financial Viability

Table E.1 provides a summary of the performance evaluation. Each of the options were rated as either good, moderate, or poor for each of the performance objectives, based upon a comparative assessment of the options.

Table E.1
Performance Evaluation Summary

	Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Lt. Rail Plus Commuter Rail	Lt. Rail Plus Express Rail
MOBILITY						
Increased Transit Use	●	◑	◑	○	○	●
Increased Transit Availability	●	◑	◑	○	○	●
Increase Traffic Flow	●	○	◑	◑	○	●
Reduce Auto Dependence	○	◑	●	○	◑	●
ENVIRONMENT						
Air Quality Improvement	◑	○	◑	○	○	●
Energy Savings	○	◑	●	○	◑	●
SOCIAL/ECONOMIC						
Core Development Support	◑	○	●	●	○	●
Service to jobs	◑	◑	◑	○	○	●
Service to Lower Income	◑	◑	◑	○	○	●
FINANCIAL						
Local Funding	●	◑	◑	○	○	◑
Federal Funding	○	●	●	●	●	◑
Long Term Value	○	●	●	●	●	◑
Future Flexibility	●	◑	◑	○	○	◑
Fare Box Recovery	○	●	●	●	◑	◑

Good ● Moderate ◑ Poor ○

The costs for each of the system options were annualized to provide total costs including both annual operation and maintenance (O & M), as well as capital and construction related items. Capital costs were annualized using a 7% discount rate and typical lifespan assumptions. **Table E.2** displays 2020 annualized costs for the various Fixed Guideway System options.

Table E.2
2020 Annualized Costs
(Millions of 1998 Dollars)

	Plan	Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Operation/ Maintenance (O&M) Cost	$146.663	$204.623	$154.536	$166.502	$159.852	$166.366	$169.779
Capital cost	$118.805	$243.875[1]	$274.941	$292.077	$302.970	$319.277	$238.358
Total Cost	**$265.468**	**$448.498**	**$429.477**	**$458.579**	**$462.822**	**$485.643**	**$408.137**

Source: MAG; BRW, October, 1998

[1] Does not include roadway improvements estimated at $74.14 Million (2020 Annualized) for Grand Ave. and Freeway HOV lane additions.

As shown, the Express Bus/Busway option includes the highest operation and maintenance cost requirements, while the Light Rail Plus Commuter Rail requires the most capital costs. The Light Rail Plus Express Bus option results in the lowest overall additional costs relative to the Plan. The Light Rail Plus Commuter Rail would be the most expensive option to construct, operate and maintain.

The following provides a summary of how well each of the Fixed Guideway System Options would address the goals and related performance objectives.

Express Bus/Busway

The Express Bus/Busway option is the second best in providing a cost-effective approach (behind Light Rail Plus Express Bus) to expanding transit services and attracting new transit riders. It rates best in congestion relief primarily due to added HOV freeway facilities. This option, however, rates poorly in reducing overall regional VMT and achieving related environmental objectives. Relative to the other options, it rates moderately in achieving social and economic goals and would have relatively poor transit farebox recovery potential.

Commuter Rail

The Commuter Rail option provides a moderately cost-effective approach to the expansion of transit services and attraction of new transit riders. This option is the least effective in providing congestion relief, while moderately effective at reducing regional VMT, auto dependence, and achieving related environmental objectives. The Commuter Rail option performs poorly in attracting CDB transit trips, as well as providing transit service to lower income households. The option performs relatively well in maximizing potential transit farebox recovery.

Light Rail

The Light Rail option provides a moderately cost-effective approach to the expansion of transit services and attraction of new transit riders. The option is also moderately cost-effective in reducing congestion; is good at reducing annual VMT and achieving related environmental objectives. The Light Rail option is also moderately cost-effective at providing transit service to jobs and lower income households. This option has the second highest (following Automated Rail) number of transit boardings per transit revenue mile and resulting potential to maximize transit farebox recovery. The Light Rail Option rates best to strengthen urban core areas and has the best potential to reshape central area land use patterns.

Automated Rail

The Automated Rail option results in one of the least cost-effective approaches to increasing regional transit service and attracting new transit riders. It performs moderately in reducing congestion, and relatively poorly in reducing annual VMT. As a result, it generally performs poorly in achieving the related environmental objective. The Automated Rail option also performs poorly in providing transit service to jobs and in serving lower income households. This option has the second highest annual operating costs as a percent of total annualized cost, while having the highest potential transit farebox recovery.

Light Rail Plus Commuter Rail

The Light Rail Plus Commuter Rail option rates as the least cost-effective approach to providing expanded transit services and attracting new transit riders. It also rates poor in congestion relief and in reducing annual VMT, and as a result, performs poorly in achieving the environmental objectives. In addition, this option is least effective in attracting Central Business District (CBD) transit trips, as well as providing transit service to jobs and lower income households. This option is also the most expensive of the Fixed Guideway System options analyzed. This option would have a moderate level of transit farebox recovery potential.

Light Rail Plus Express Bus

The Light Rail Plus Express Bus option is the most cost-effective approach to providing expanded transit services. It also rates high in reducing congestion and reducing annual VMT, and achieving the related environmental objectives. The Light Rail Plus Express Bus option ranks first in providing transit service to CBD trips, service to jobs and lower income households. The option would provide moderate potential to maximize transit farebox recovery.

E.7 Transit Related Benefits

The focus of this study has been on a comparative analysis of various fixed guideway technologies and system configurations. The analytical approach required a quantification of both costs and ridership as key measures of the performance of each of the system options. The quantification of ridership data by low-income groups and transit service to key activity centers were extrapolated as measures of effectiveness in addressing related environmental, social and economic goals.

As part of the evaluation process, it is also important to acknowledge other transit related benefits, many of which are more difficult to quantify. These include:

- Ability to encourage denser land use patterns in central travel corridors and key activity centers.
- Provision of improved and expanded mobility options for groups which are traditionally mobility disadvantaged, including the low-income, elderly, disabled, and students.
- Provision of additional mobility options for groups which are traditionally auto dependent, including workers and commuters.

It should also be kept in mind that this fixed guideway study is a system level analysis and more detailed analyses at the corridor level are warranted. Some factors that could result in higher fixed guideway ridership estimates include the following:

- The MAG transportation model is in the process of being reconstructed to be more sensitive to alternative transit technologies.
- A major fixed guideway investment could be associated with plans for transit oriented land use patterns in central corridors.
- Downtown sporting and other events are not fully considered in current MAG models.
- More detailed model network coding could better capture land use concentrations around stations and connections between the fixed guideway facility, local bus, and other modes.
- At the corridor level, plan details can be more effectively addressed including alignments, station and parking costs.
- At a more detailed level of analysis, each mode can be more closely assessed to insure that strengths of each mode are captured and that modal interconnections are fully addressed.

E.8 Recommendation for a Fixed Guideway Transit Concept

Based on the study results, a fixed guideway transit concept is recommended for further study. The basis of the recommended concept is the Light Rail Plus Express Bus Option. The concept also includes expanded local bus service.

System Concept

In the recommended option, each transit service type meets specific needs: Local bus service is the largest component of the system since it provides services throughout the Valley all day long and is particularly important in meeting the needs of the transit dependent. LRT is targeted for the highest demand corridors to expedite transit service and meet peak hour demands. LRT is

also an economic development tool and can help create an alternative land use pattern with transit oriented development concentrated in core areas.

Express bus service is adjusted to serve outlying areas not served by light rail. Its peak hour focus is on serving commuters and relieving rush hour traffic. Shuttle service is used to expand the service areas of LRT and express bus in core areas.

System Elements

The basis of the recommended concept is the Light Rail Plus Express Bus option. It includes an expansion of local bus service, a light rail transit (LRT) system and expanded express bus service. **Figures E-2**, **E-3**, and **E-4** display the light rail, express bus, and local bus component of the recommended transit system concept.

The proposed Light Rail Plus Express Bus option includes the following elements:

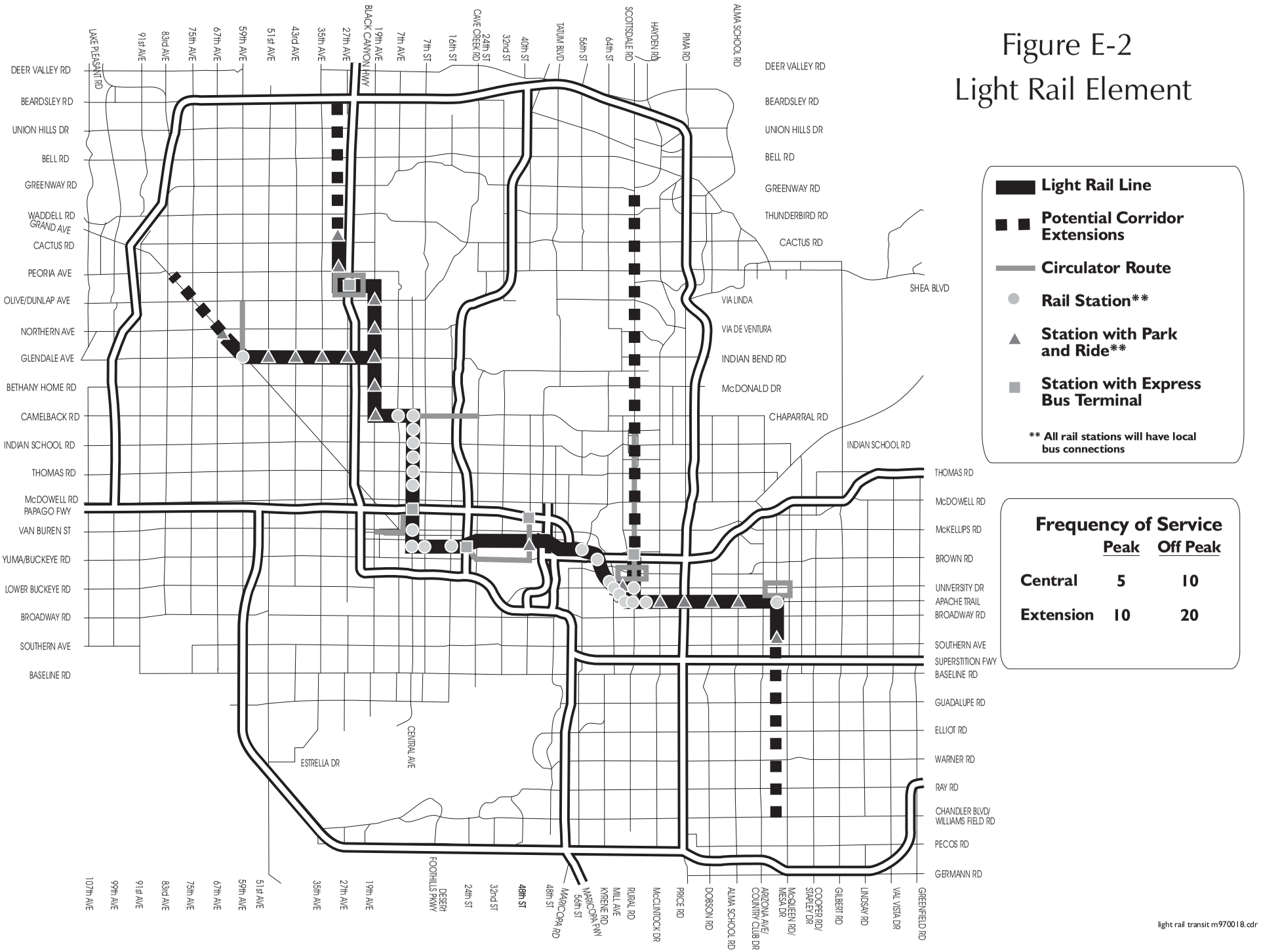
- A 39-mile light rail transit (LRT) system focused on serving central activity centers. Potential future extensions to Peoria, Scottsdale, Chandler and the Deer Valley Village Core have also been identified. The initial LRT segment is now in the preliminary engineering and environmental impact study phase.
- Expansion of express bus service to connect outer urbanized areas to central activity centers. The manner and extent to which express buses circulate within residential and employment areas will need to be addressed in future studies.
- A tripling of local bus service to provide transit mobility throughout the urbanized area. This will include incorporating all local transit plans as developed by the RPTA and the local jurisdictions.
- A major expansion of circulator service in core areas to expand the service areas of express bus and light rail services.
- Commuter bus connections to outlying communities.
- Improvements to bus stops including shelters and bus pullouts.
- A tripling of Dial-a-Ride service to meet paratransit transportation needs.

Funding Concept

A variety of funding strategies could be developed to support the proposed fixed guideway concept (Light Rail Plus Express Bus Option), each involving some combination of funds from the following types of sources:

- Federal formula and discretionary grant programs;
- State discretionary transportation funds;
- Regional (countywide) dedicated revenue mechanism (sales tax or other);
- Local (city and county) dedicated revenue mechanisms (sales tax and/or other);

Figure E-2
Light Rail Element



Light Rail Line

Potential Corridor Extensions

Circulator Route

Rail Station**

Station with Park and Ride**

Station with Express Bus Terminal

** All rail stations will have local bus connections

Frequency of Service

	Peak	Off Peak
Central	5	10
Extension	10	20

light rail transit m970018.cdr

Figure E-3
Express Bus Element

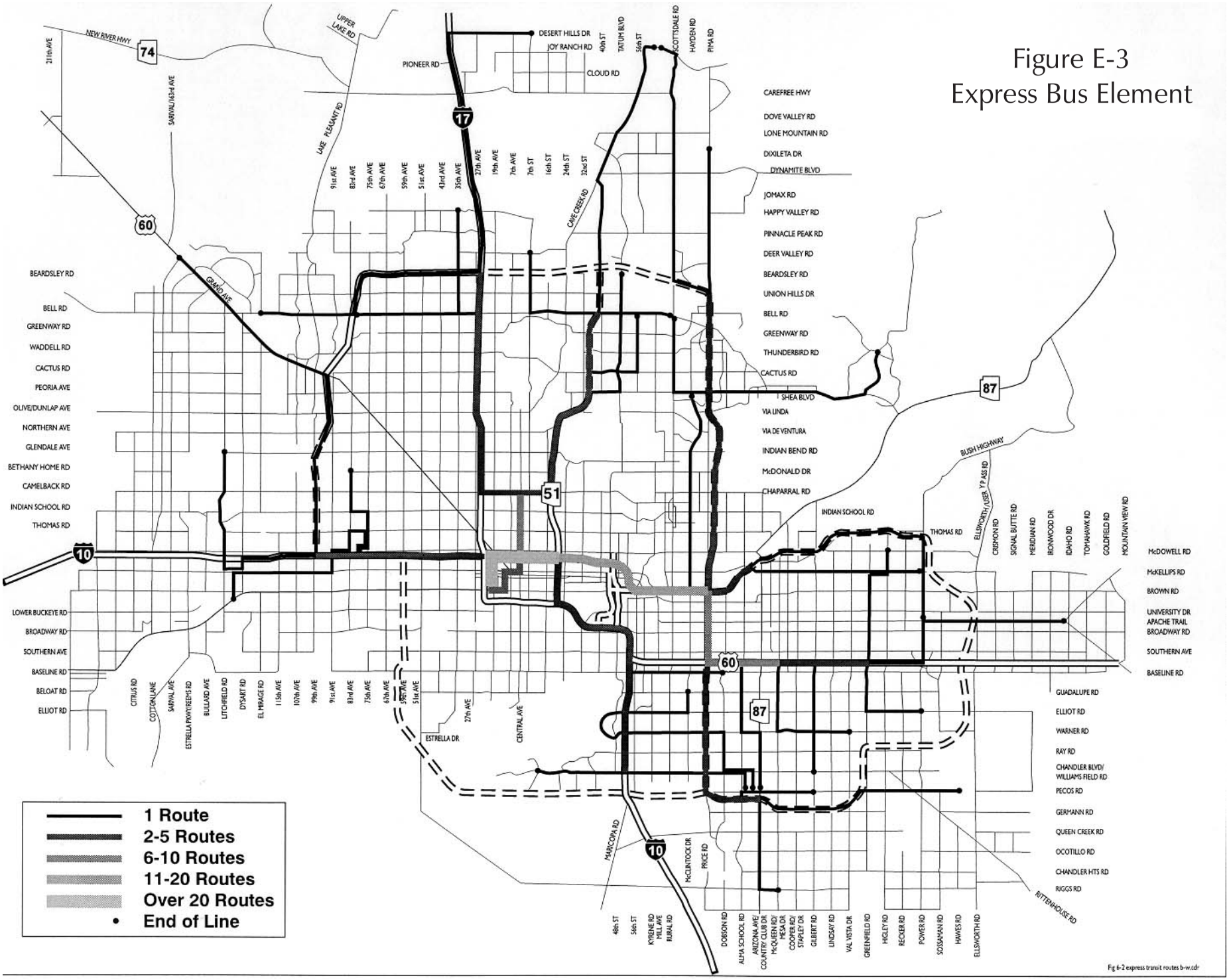
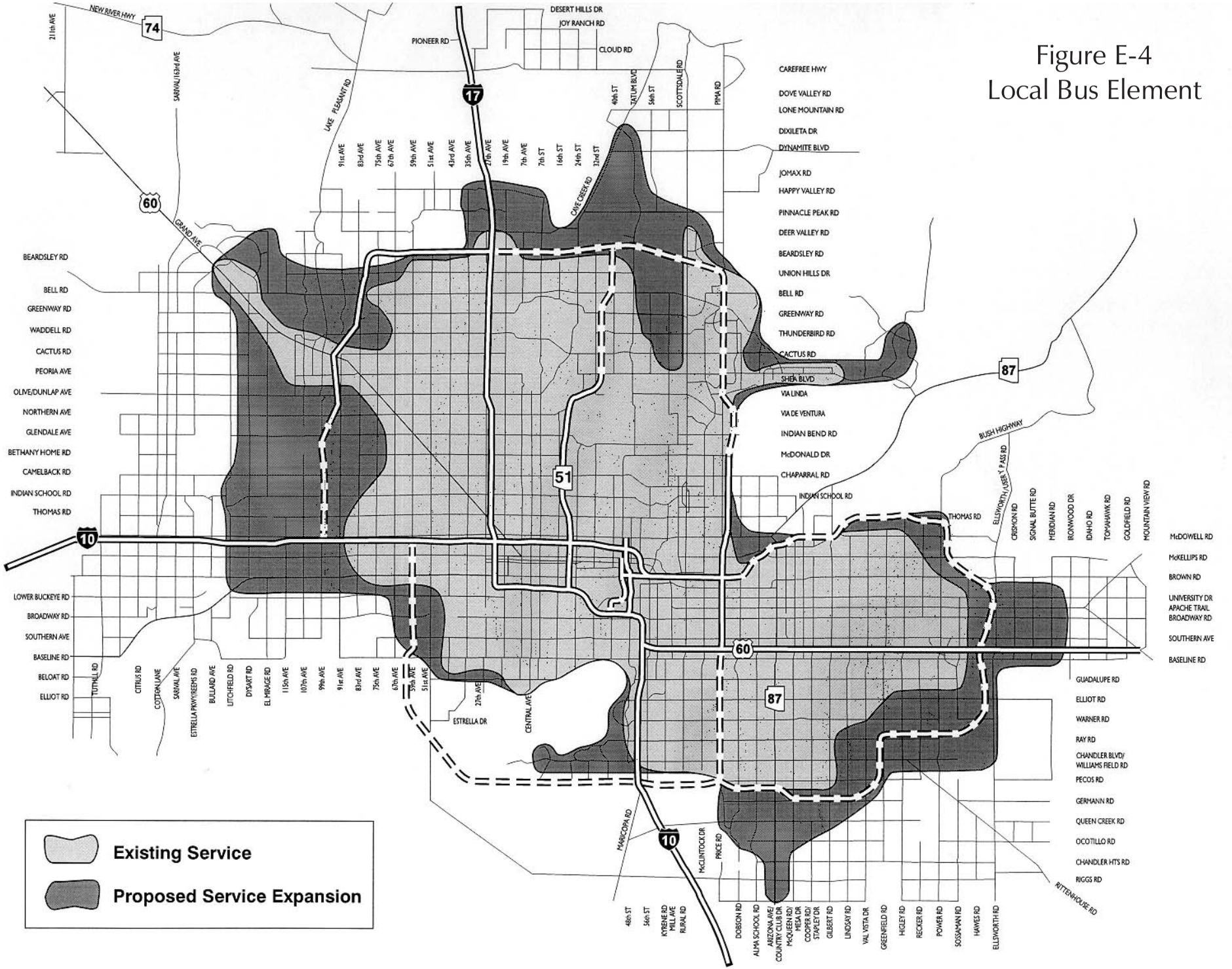


Figure E-4
Local Bus Element



- Local (city and county) discretionary funds; and
- Private sector contributions.

In general the combined total systemwide capital and operating cost of the proposed concept over 21 years (to 2020) could be covered with the revenue equivalent to a 0.65% countywide sales tax over that same period. In reality, as much a 40 percent of the total funding need could be met from sources other than local and regional sales taxes, potentially including:

- Transit Fares
- Federal Discretionary Rail "New Start" Funds
- Federal Formula transit Assistance Funds
- MAG/Federal CMAQ Funds
- Arizona LTAF Funds
- Local General Funds

Under this scenario, the required contribution from some combination of dedicated regional and local taxes would be reduced to the equivalent of a 0.4% countywide tax.

1.0 Introduction

This report, the Maricopa Association of Governments (MAG) Fixed Guideway System Plan, was undertaken as part of the Regional Transit System Corridor Studies project as a cooperative effort between MAG and the cities of Phoenix, Tempe, Scottsdale, Glendale and Mesa. The purpose of the MAG Fixed Guideway System Study was to assess and develop the most viable fixed guideway concept for the Phoenix metropolitan area. The study considered the inclusion of a fixed guideway element or system into the MAG Long Range Transportation Plan (LRTP). The study also serves to identify corridors that warrant additional study.

The MAG Fixed Guideway System Plan effort is one of a number of studies undertaken to address travel demand and mobility needs in the Phoenix metropolitan area. The studies consist of:

- MAG Fixed Guideway System Study
- Central Phoenix East Valley Major Investment Study (MIS)
- Glendale/North Phoenix Major Investment Study (MIS)

In addition, MAG and ADOT have initiated the Grand Avenue MIS which will address highway and transit improvements in the Grand Avenue Corridor.

1.1 Study Process

This study was completed by BRW and HLB-Decision Economics in cooperation with MAG staff. The MAG Regional Council has confirmed that oversight be jointly provided by the MAG Transportation Review Committee (TRC) and the Regional Public Transit Authority (RPTA) Valley Metro Operations Staff (VMOS).

The study process includes the following seven tasks:

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These results of these tasks are documented in the chapters of this report.

The MAG Fixed Guideway System Study addresses regional transportation system needs. This study could lead to including one or more of fixed guideway corridors into the MAG Long Range Transportation Plan to be further refined at the corridor level through Major Investment Studies (MIS). The MAG Fixed Guideway System Study was pursued in close coordination with four Major Investment Studies in the region which began concurrently:

- The Glendale/North Phoenix MIS
- The Scottsdale MIS was started but is no longer active.
- The Downtown Tempe/ASU/Rio Salado MIS was combined with the Central Phoenix/East valley MIS.
- The Central Phoenix/East Valley MIS.

On January 22, 1997 the MAG Regional Council approved a fixed guideway starter corridor for inclusion in the draft FY 1997 update of the MAG Long Range Transportation Plan for Conformity Analysis. This analysis has been completed and the plan was approved in September 1997. The corridor extends along Central Avenue in Phoenix, and then extends east from downtown Phoenix to downtown Tempe and into Mesa. Congress has approved $4 million in FY 1998 for preliminary engineering for this corridor. The RPTA Board of Directors endorsed the MIS results for this corridor in may, 1998, which includes light rail transit and supporting bus options. The City Councils of Phoenix, Tempe and Mesa approved local funding match for continuing LRT studies in September, 1998.

1.2 Report Organization

Following this **Introduction** chapter, **Chapter 2.0** provides a summary of previous studies which reviewed various fixed guideway options to address regional and local corridor travel needs in the Phoenix metropolitan area. **Chapter 3.0** reviews regional travel patterns and identifies key high demand travel corridors which could potentially be served by high capacity transit facilities and technologies. **Chapter 4.0** reviews various transit technologies including local bus, express bus, light rail transit, automated light rail, and commuter rail, and identifies options for further evaluation. The evaluation results of the fixed guideway system option are then summarized in **Chapter 5.0**. **Chapter 6.0** presents a recommended fixed guideway transit concept for consideration as an input to the long-range transit component of the MAG Regional Transportation Plan.

2.0 Previous Studies

The purpose of this chapter is to document previous studies that have examined fixed guideway transit systems for the Phoenix metropolitan area. To the extent feasible, data such as alignments, stations, technology, ridership, operating and capital costs, cost-effectiveness indicators and financial feasibility have been included to facilitate the review of previous fixed guideway system proposals.

The key fixed guideway planning studies that have been completed in the past include the *Transit Systems Planning Study*, the *MAG Regional Transportation Plan Fixed Guideway System Study*, the *Arizona Rail Passenger Feasibility Continuation Study*, the *Phoenix Transit Plan - Camelback to CBD Corridor*, the *Phoenix Downtown Rail Trolley Feasibility Study*, and the *Commuter Rail Demonstration Project*.

Information summarized for each study includes:

- Study Purpose and Objectives
- Key Findings and Recommendations

2.1 Transit Systems Planning Study

The *Transit Systems Planning Study* (CRS Sirrine, Inc.; March 1988) was conducted for the Regional Public Transportation Authority (RPTA). The study culminated with recommendations for a long-range transit system plan. Several supporting technical studies were completed to analyze transit technology alternatives and candidate transit corridors.

2.1.1 Study Purpose and Objectives

The primary goal of the *Transit Systems Planning Study* was to identify a preferred system level transit alternative that met requirements related to performance, costs, and community and environmental acceptability. The transit system plan was developed in anticipation of the passage of a cent sales tax increase sought by the RPTA in 1989. While the sales tax increase did not pass, the funds would have been dedicated to the development of a rapid transit system in the Phoenix metropolitan area. A similar sales tax increase was passed in 1985 for improving transportation services over a 20-year timeframe, with the majority of revenue dedicated to improving the Valley's freeway system.

2.1.2 Key Findings and Recommendations

The *Transit System Planning Study* system development process began with the identification of system level alternatives consisting of combinations of individual transit corridors, technologies, levels of service and access variations. Based on an initial corridor and segment evaluation, a fixed guideway transit system of approximately 100 miles in length was proposed for Maricopa County.

Three concept alternatives were developed for application in the most cost-effective corridors/segments. These alternatives included the following:

- Mini-metro: Fully grade-separated, automated rapid transit (ART) technology (67-mile concept plan)
- Light Rail Transit (LRT): Partially grade-separated manually operated, electrified system (90-mile concept plan)
- Busway: Combination of mini-metro and LRT corridors created around the expanding regional freeway system (124-mile concept plan).

Capital costs range from $1.0 to $3.35 billion for the mini-metro system, $1.7 to $2.74 billion for LRT, and $2.44 to $3.25 billion for the busway system. **Figure 2-1** illustrates the recommended rapid Transit Plan. The study concluded that the transit system could be implemented and operated over a 25-year period with funding projected to be available from existing and projected revenue sources, including the ½ cent sales tax referendum which subsequently failed in 1989.

2.2 MAG Long Range Transportation Plan (LRTP) Summary and 1993 Update

The following section describes the *MAG Long Range Transportation Plan (LRTP) Summary and 1993 Update*.

2.2.1 Study Purpose and Objectives

The Maricopa Association of Governments is responsible for integrating a regional transit plan into the Regional Transportation Plan. The *MAG LRTP Summary and 1993 Update* provided a Short Range Transit Plan and a Long Range Transit Plan, as well as a summary of transit funding assumptions.

2.2.2 Key Findings and Recommendations

Following the completion of the *Transit Systems Planning Study*, the *MAG Long Range Transportation Plan (LRTP) Summary and 1993 Update* included a reduced 35-mile fixed guideway system concept for completion by year 2020. This fixed guideway element, illustrated in **Figure 2-2**, was subsequently removed due to requirements for a fiscally constrained 2015 Regional Transportation Plan, and very limited dedicated funding sources for transit. This fixed guideway system included a link in the Central Phoenix corridor with connections to downtown Glendale, Sky Harbor, Downtown Tempe, downtown Scottsdale and downtown Mesa.

2.3 Arizona Rail Passenger Feasibility Continuation Study

The *Arizona Rail Passenger Feasibility Continuation Study: Project Planning Report* (Kimley-Horn and Associates, Inc.; June 1994) was conducted by the Arizona Department of Transportation (ADOT) and documents follow-on project planning of recommendations contained in the preceding *Arizona Rail Passenger Feasibility Study* (November 1993).

Figure 2-1

Transit Systems Planning Study

Proposed Rapid Transit Plan

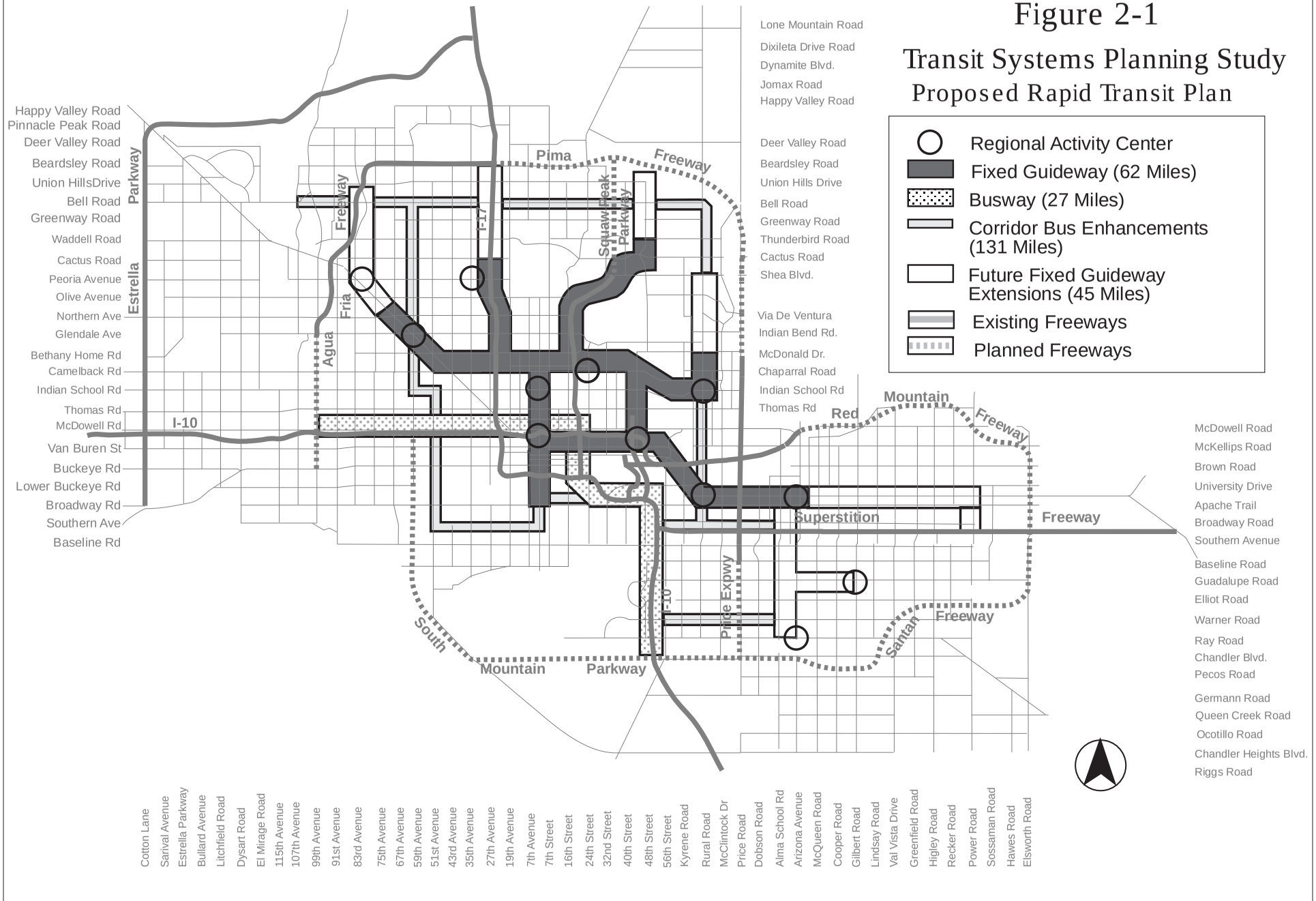
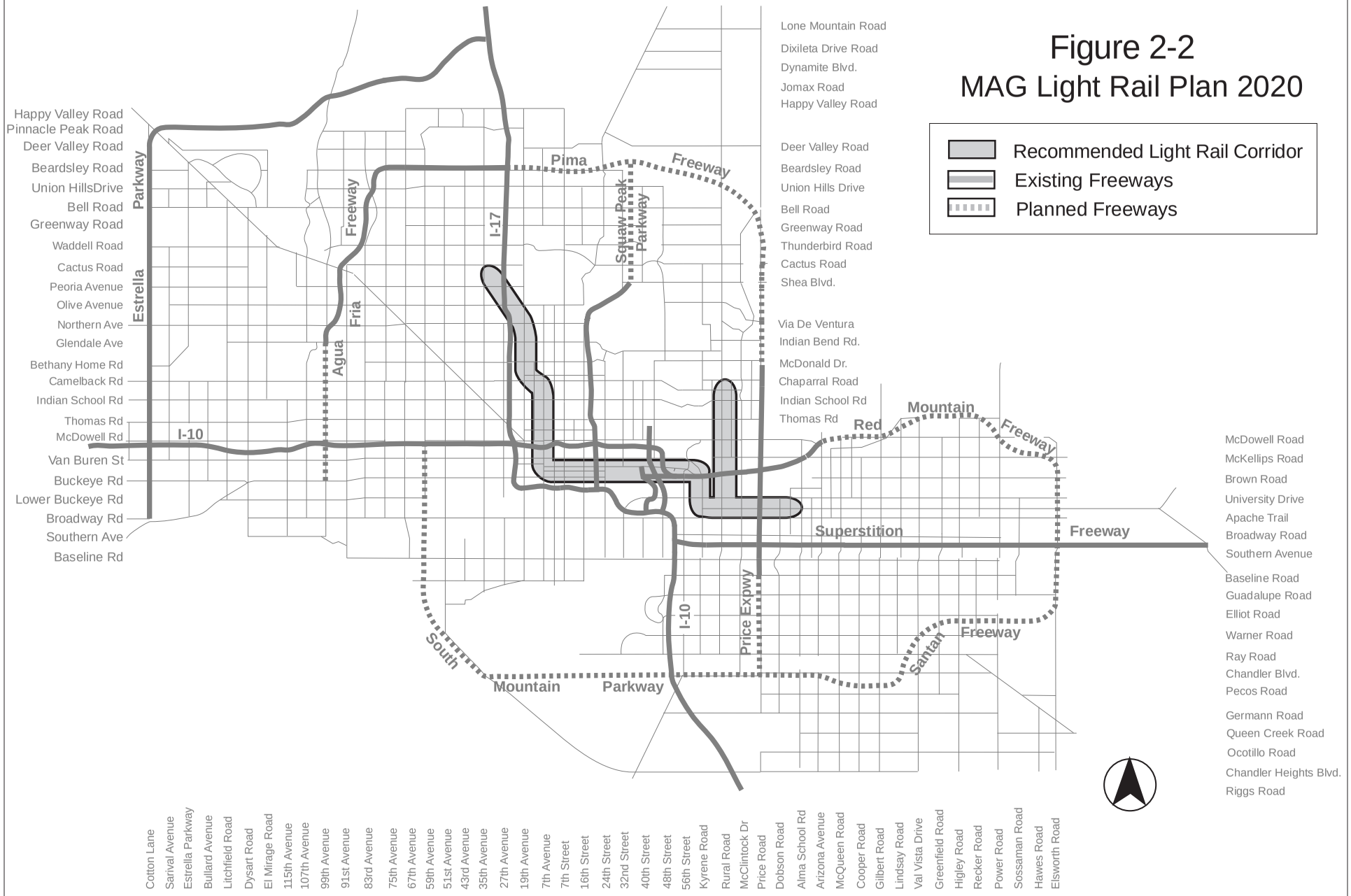


Figure 2-2
MAG Light Rail Plan 2020



2.3.1 Study Purpose and Objectives

The purpose of the *Arizona Rail Passenger Feasibility Continuation Study: Project Planning Report* was to perform more detailed planning-level work on two projects:

- Phoenix-Tucson-Nogales intercity rail project; and,
- Phoenix-area commuter rail project Commuter Rail Line.

The objectives of the project planning process were to better define ridership estimates, operating and maintenance cost estimates, and capital cost estimates associated with each rail line. The report also made a number of recommendations related to implementation.

2.3.2 Key Findings and Recommendations

The following sections provide a description of the key characteristics of the projects.

Phoenix-Area Commuter Rail Project

The Phoenix-area commuter rail project was found to have the highest ridership productivity (measured as forecasted riders per mile) of all the projects recommended in the preceding 1993 ADOT study. As shown in **Figure 2-3**, this rail line would serve the Phoenix Central Business District (CBD)and operate as a northwest-to-southeast commuter rail line between the Glendale-Peoria area and the Tempe, Mesa, Gilbert areas.

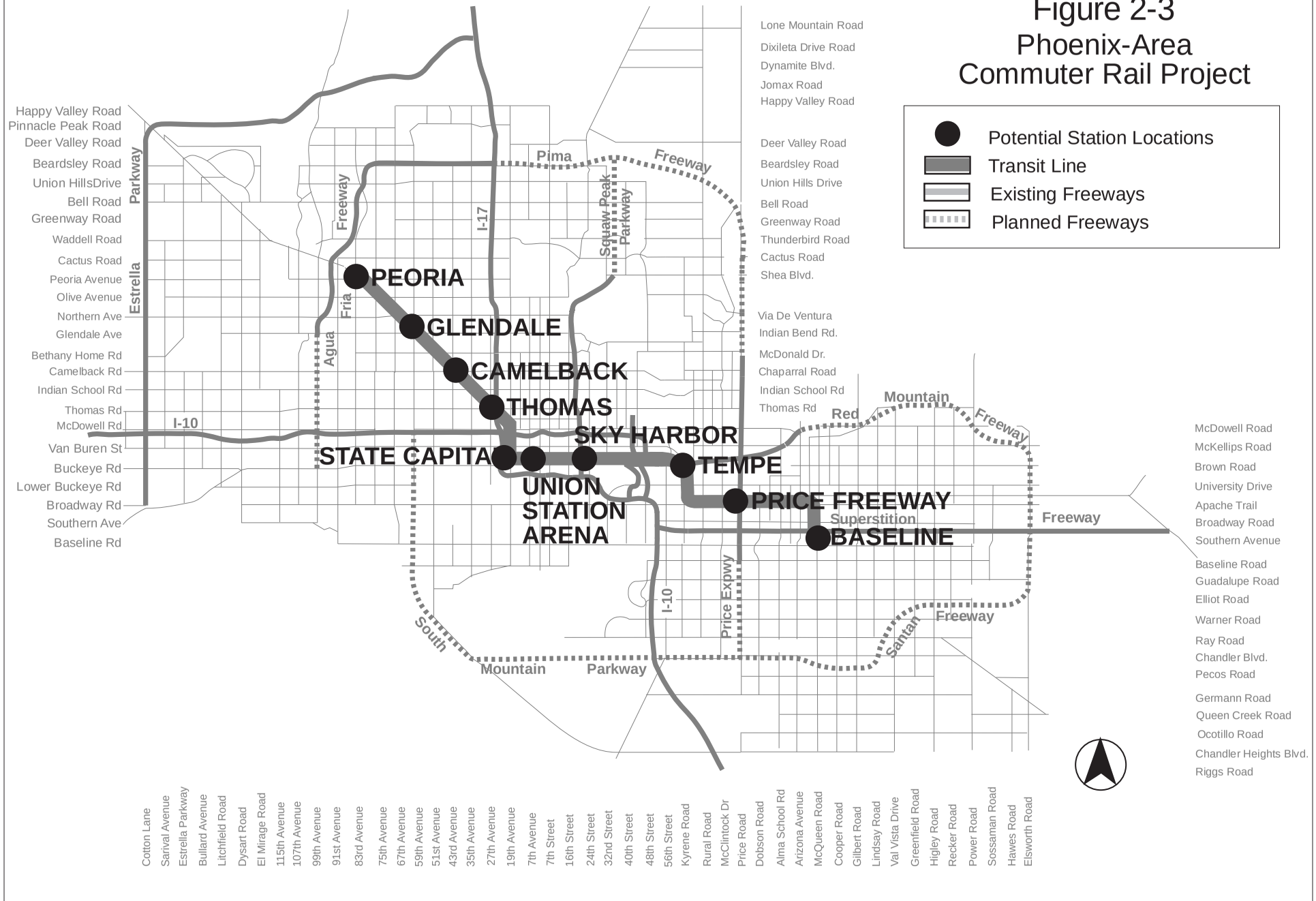
The 33-mile corridor would use the existing Burlington Northern/Santa Fe tracks in a southeasterly direction, paralleling Grand Avenue from Peoria to the vicinity of the State Capitol. The alignment would then switch to the Union Pacific Railroad tracks and proceed east through downtown Phoenix to the Sky Harbor International Airport, Tempe, and Mesa, terminating in Gilbert.

Phoenix-Tucson-Nogales Intercity Rail Project

While the Phoenix-area commuter rail project was shown to have the highest ridership productivity, the Phoenix-Tucson intercity rail project was found to have the higher ridership potential of the two projects (2.3 million vs. 1.6 million annual riders). As compared to commuter rail, intercity rail is defined as a long-distance rural passenger service between metropolitan areas. Routes are generally more than 100 miles in length, with station spacing at least 20 miles apart. Such projects typically share existing freight railroad Trackage or rights-of-way.

By combining this rail project with the Tucson-Nogales intercity rail extension, the project would connect Phoenix and Tucson, the two largest metropolitan areas in Arizona, with the primary port-of-entry to Mexico at Nogales. **Figure 2-4** illustrates the location of the corridor. The study noted that increased mobility and access would benefit corridor travelers, but in addition the project would also have the potential to increase economic development through the

Figure 2-3
Phoenix-Area Commuter Rail Project



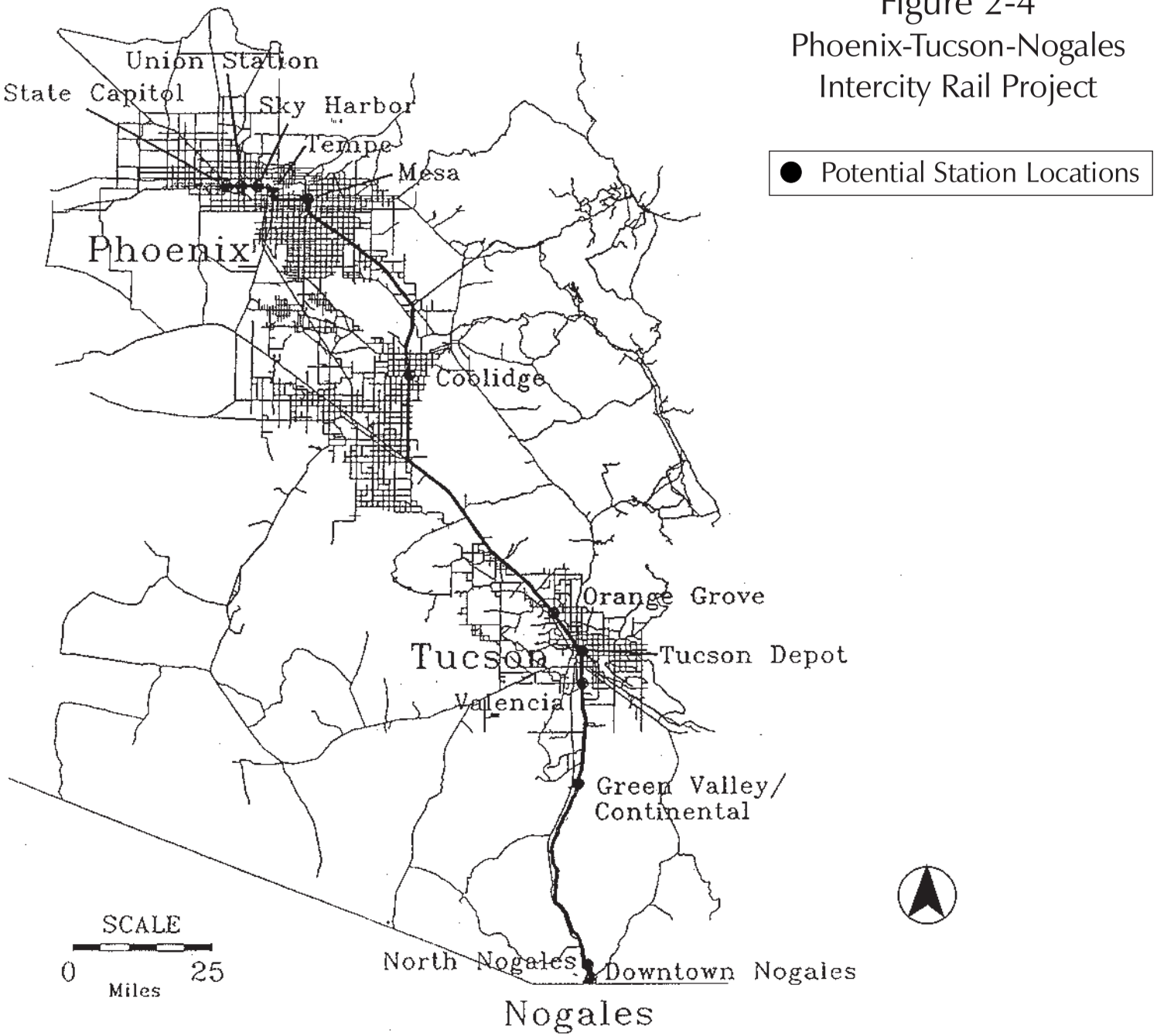


Figure 2-4
Phoenix-Tucson-Nogales
Intercity Rail Project

promotion of trade between Arizona and Mexico, particularly in light of the North American Free Trade Agreement (NAFTA).

2.4 City of Phoenix Transit Plan

The *City of Phoenix Transit Plan Summary* was completed in July 1990. One of the elements of the Transit Plan is rail transit service.

2.4.1 Study Purpose and Objectives

The *Transit Plan Summary* outlined the provision of bus, rail, on-demand transit services and other alternative modes of transportation (shuttles, bike paths, etc.) for the City of Phoenix. Budget allocations were made for each element and recommendations for making up the local funding shortfall were made.

2.4.2 Key Findings and Recommendations

The key portions of this study relevant to the current study relate to the rail element of the transit plan. The rail element was included as a demonstration project patterned after light rail systems in cities such as San Diego and Portland. The rail service would be at-grade and operate over an approximately 10-mile route. Stations would be provided every ½ to 1 mile. **Figure 2-5** shows the conceptual alignment location. As shown, the route would extend from the area of I-17/Camelback Road to Central Avenue, then along the Central Corridor through the Encanto and Central City village cores (Park Central Mall and downtown Phoenix), through the Sky Harbor Center and to the vicinity of the airport. The alignment would generally operate within the street system in its own traffic lane. The service would operate from 5:00 a.m. to midnight Monday through Saturday, and from 6:00 a.m. to 8:00 p.m. on Sundays and holidays. Peak headways would be five minutes; off-peak would be 10 to 15 minutes.

2.5 Phoenix Downtown Rail Trolley Feasibility Study

The *Phoenix Downtown Rail Trolley Feasibility Study* (BRW, Inc.; September 1995) was developed to assist the City of Phoenix in evaluating the feasibility of installing a fixed rail line and operating trolley system in downtown Phoenix.

2.5.1 Study Purpose and Objectives

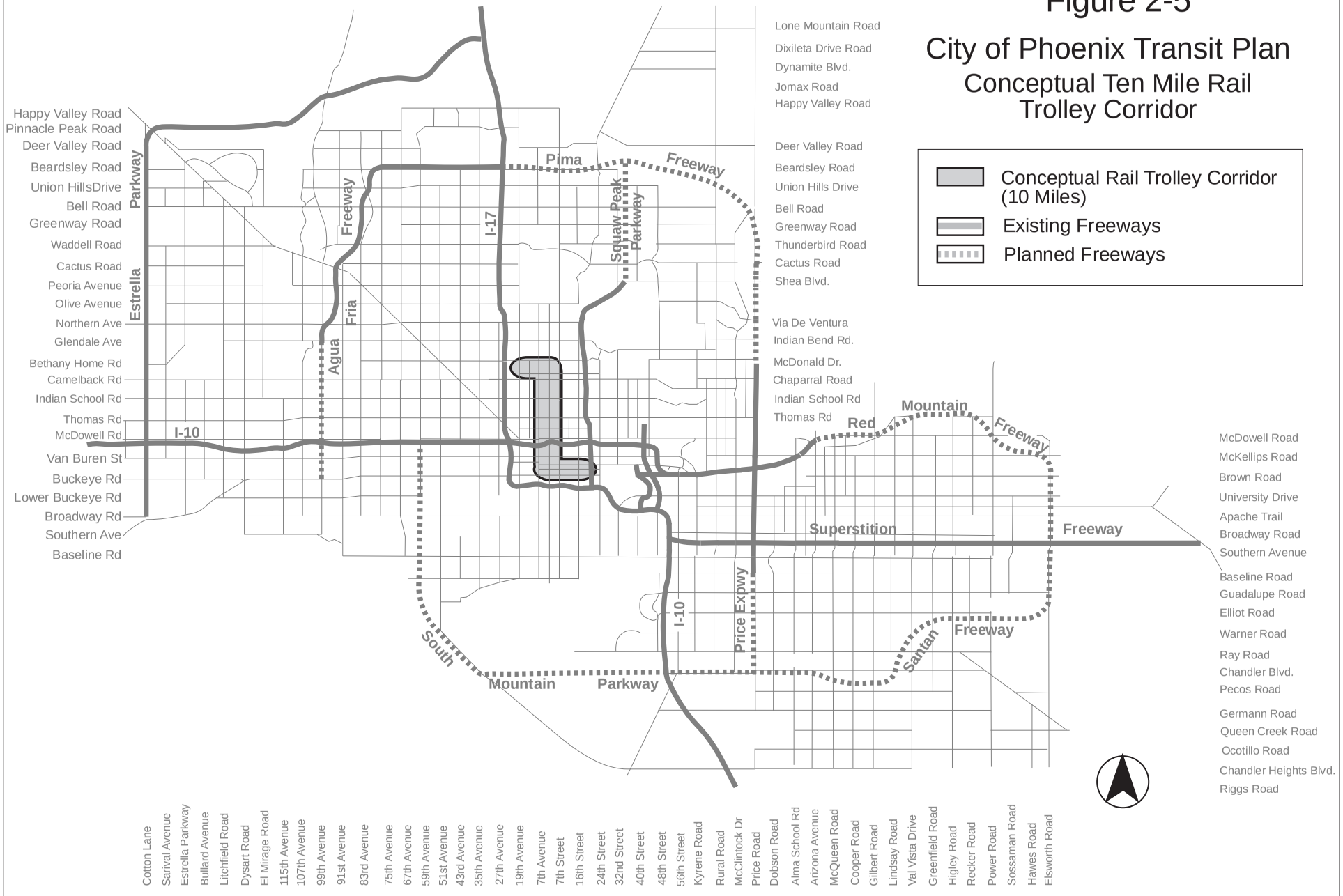
The feasibility study based a downtown Phoenix trolley system on five interrelated goals to continue downtown renaissance with the addition of a functional transportation system element, which itself could become an attraction. The goals of the study are summarized below:

- To maintain a viable core in downtown Phoenix.
- To add an element of interest to the downtown area which will serve as a transportation mode linking activity centers, and serving as an attraction itself.
- To enhance the availability of alternative modes of mass transit on Central Avenue as envisioned by the City of Phoenix and the Downtown Specific Plan.

Figure 2-5

City of Phoenix Transit Plan

Conceptual Ten Mile Rail Trolley Corridor



- To enhance quality of life through improved air quality and congestion relief.
- To provide a working demonstration of the popularity and workability of electric rail transit, as a precursor to future urban transit lines.

2.5.2 Key Findings and Recommendations

The study found that the implementation of a rail trolley in downtown Phoenix would result in several benefits. In addition to providing an alternative mode of transportation in the downtown area, a trolley system could act as a catalyst for land use development, definition and enhancement of activity centers, as well as contribute to tourism growth. Furthermore, such a project could enhance the urban design framework for downtown Phoenix, as well as provide an element of safety which is important to the growth and attractiveness of urban areas. A trolley with vintage character would create the greatest interest as an additional attraction to downtown, although a replica trolley would be suitable.

Four final candidate alternative alignments were evaluated in the study: the Green, Red, Yellow, and Orange Alternatives. **Figure 2-6** illustrates the locations of the alternative alignments and station locations. The Orange Alternative was selected as the preferred alternative.

2.6 Commuter Rail Demonstration Project

The *Commuter Rail Demonstration Project* report was prepared in September 1994 by the RPTA in cooperation with ADOT, MAG, and the Arizona Rail Passenger Association. Three potential commuter rail corridors were evaluated.

2.6.1 Study Purpose and Objectives

The commuter rail demonstration project presented an opportunity to provide additional transportation services during an anticipated high tourism period (Fall 1995 to Spring 1996). This tourism period was associated with the Fiesta Bowl, Phoenix Open and Super Bowl XXX, and was expected to place an even greater strain on the region's limited transportation network.

2.6.2 Key Findings and Recommendations

Figure 2-7 shows the three potential commuter rail demonstration corridors. The Northwest Valley corridor was not retained as a potential corridor for the demonstration project. A description of the West Valley and East Valley corridors is provided below:

West Valley Corridor **-** This corridor extends from downtown Phoenix westerly to the communities of Tolleson, Avondale, Goodyear and eventually to Los Angeles on the mainline Phoenix Line portion of the Southern Pacific (SP) railroad. The corridor is used for freight and was used for intercity passenger (AMTRAK) service.

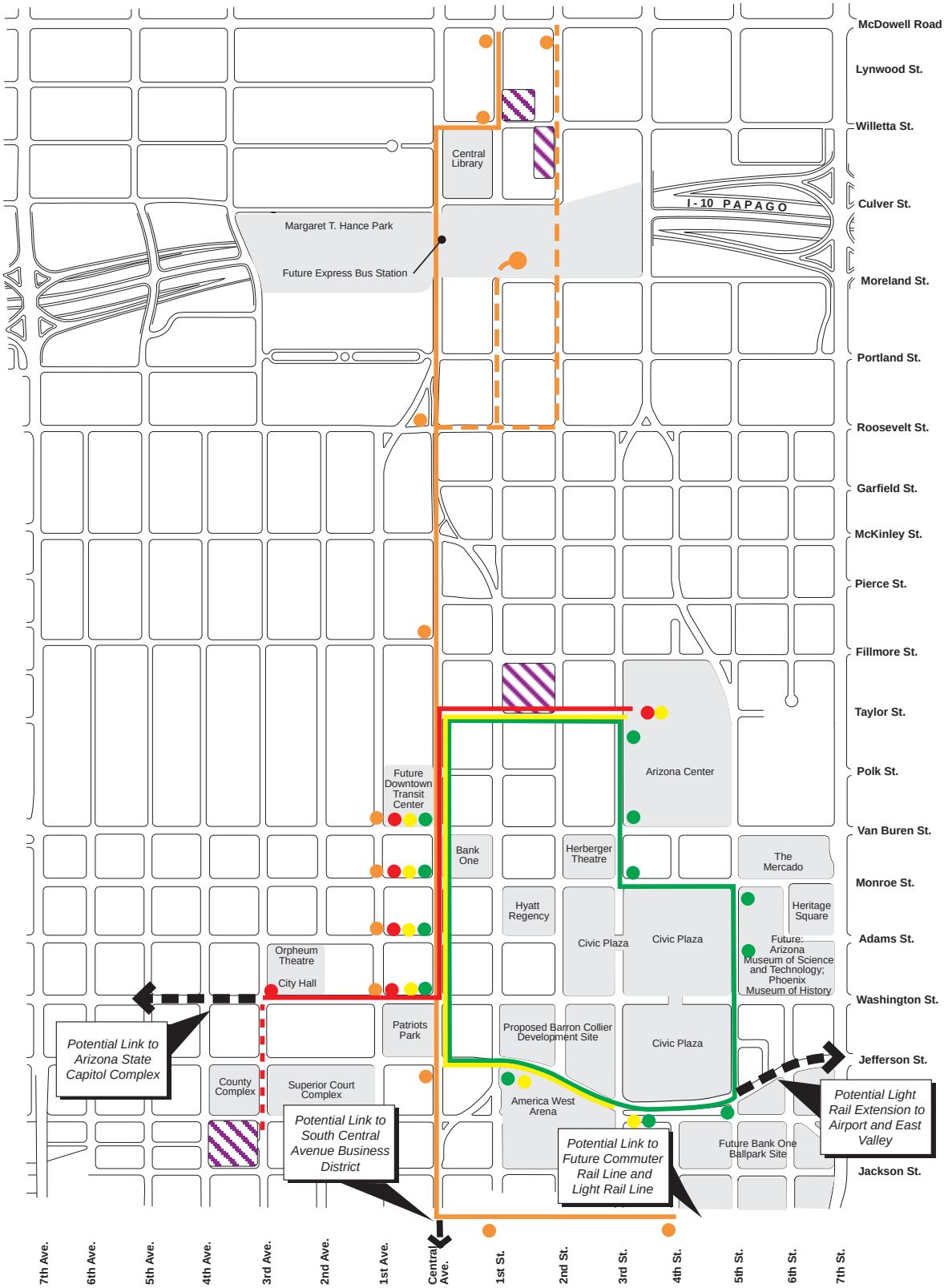


Figure 2-6

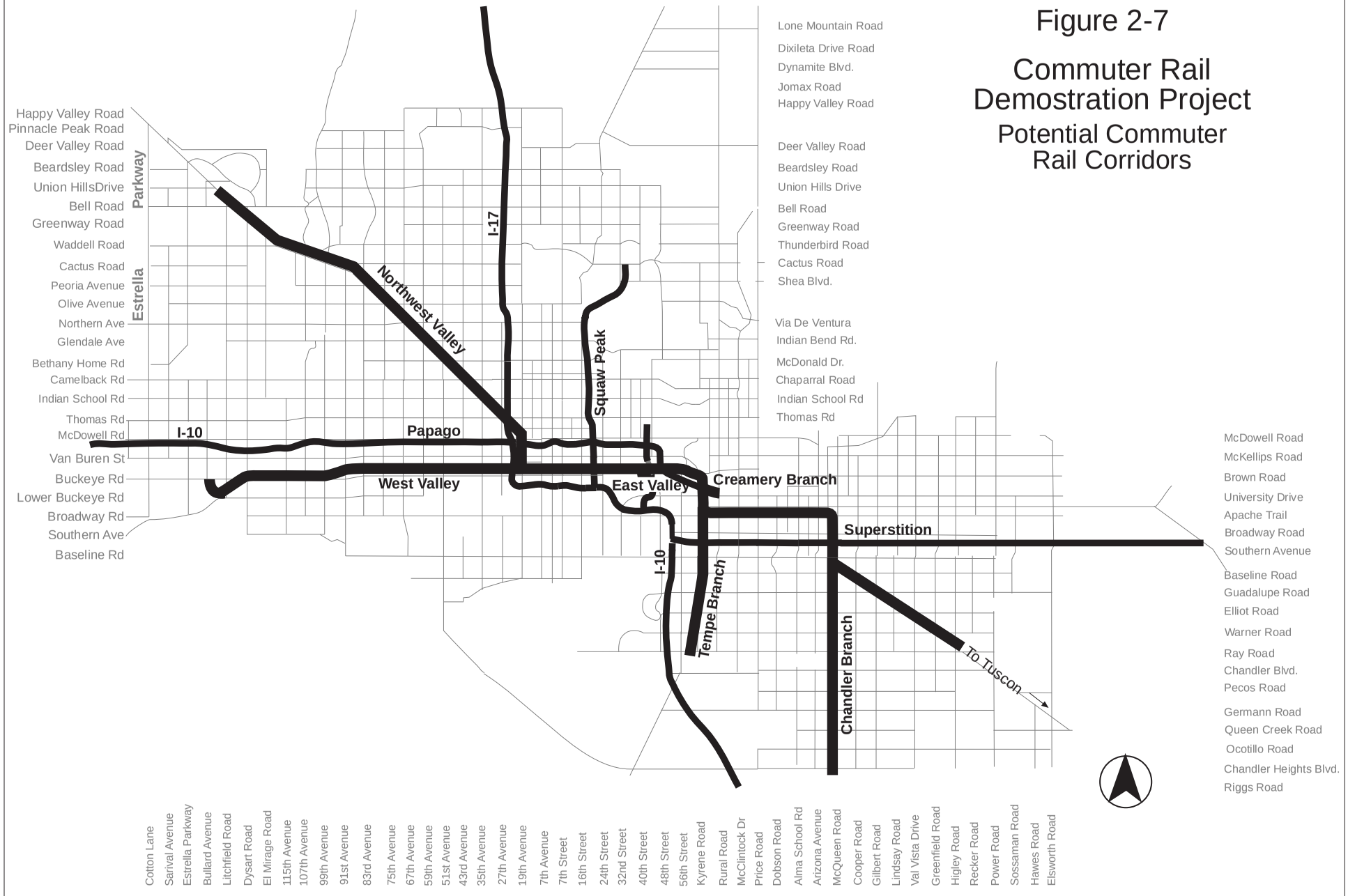
Phoenix Downtown Rail Trolley Feasibility Study

Final Candidate Alignment and Station Location Alternatives

Figure 2-7

Commuter Rail Demostration Project

Potential Commuter Rail Corridors



East Valley Corridor **-** This corridor is part of the same SP mainline (Phoenix Branch) of the West Valley Corridor, and extends from downtown Phoenix easterly to Tempe, Mesa and then south to Tucson. This corridor also includes the Tempe and Chandler branches, as well as the Creamery Branch which extends to Sun Devil Stadium.

Description of Initial Service

The proposed 42-mile route would have begun in downtown Chandler and extended west through Mesa, Tempe, Phoenix, Tolleson and Avondale, ending in the City of Goodyear.

Ten stations with raised boarding platforms and parking facilities would be provided as follows:

- Downtown Chandler
- Baseline Road
- Alma School Road
- Tempe Depot
- Sky Harbor Airport
- Downtown Phoenix
- State Capitol
- 59th Avenue
- 91st Avenue
- Phoenix/Goodyear Airport

Service would be provided on 60-minutes headways during peak hours along the West Valley Corridor. No off-peak service would be provided due to conflicts with freight operations. In the East Valley Corridor, 30-minute headways during the peak hour and 60-minute off-peak service would be provided. Service would be from approximately 6:00 a.m. to 6:00 p.m.

2.7 Summary

Through the previous transit system planning efforts documented in this chapter, several high travel demand and cost-effective corridors have been identified for the region. Furthermore, the findings of each individual study contribute to the definition of the purpose and need for a well-defined regional transit plan.

The *Transit Systems Planning Study* documented the increasing travel demand in the greater Phoenix metropolitan area. This demand provided the primary basis of the need for an alternative mode of transportation. The study found that daily vehicle travel was projected to increase by 220 percent over the 1985 level to just under 120 million miles by the year 2015 within metropolitan Phoenix. This growth was accounted for by population growth and an increase in average daily vehicle trip length. While existing and new freeway facilities were expected to carry nearly 40 percent of all vehicle miles of travel (VMT), the total growth in the roadway network is not expected to keep pace with the increase in travel demand. As stated in

the *Transit Systems Planning Study*, increases in travel demand tend to result in lower levels of service (LOS) and longer travel times, as well as higher environmental impacts related to noise, air quality and community disruption.

A comprehensive regional fixed guideway transit plan should integrate the need for commuter and intercity rail, as well as the benefits associated with novelty systems such as a downtown rail trolley. These types of systems can serve specific functions within the context of a regional system while meeting specific goals and objectives related to traffic, land use, economic development, and the environment.

In summary, previous studies have indicated that the development of a regional fixed guideway transit system can meet the following needs of Maricopa County:

- Reduce traffic congestion and improve levels of service through the provision of an alternative mode of transportation;
- Improve mobility and access to activity centers within the region;
- Enhance quality of life and the environment (air quality, noise, congestion);
- Enhance economic development opportunities;
- Strengthen and enhance activity centers.

3.0 High Demand Transit Corridors

3.1 Fixed Guideway Standards, Thresholds and Related Evaluations Practice

This chapter summarizes regional travel patterns, and the distribution of key socio-economic characteristics as the basis for identification of high demand transit corridors. Specific objectives covered include the following:

- Identify and review applicable standards, thresholds and evaluation considerations which determine the suitability of fixed guideway facilities in key travel corridors.
- Review socio-economic factors including population and employment growth and densities, regional travel patterns, and location of major activity centers which may support future fixed guideway transit facilities.
- Identify the magnitude and pattern of travel demands and access levels of congestion and underserved demand in key regional travel corridors.

A set of high demand regional travel corridors were then selected for further review as potential fixed guideway transit corridors.

This section reviews the various general practices and processes wherein fixed guideway corridors are defined, evaluated and chosen for implementation. Where applicable, standards and thresholds relative to cost, ridership and local service requirements are presented.

The fixed guideway corridor evaluation process is typically performed on an iterative basis, often requiring successive application of objectives, criteria, standards and thresholds. The fixed guideway corridor evaluation process commonly consists of two distinct, though related activities:

1. Corridor delineation and definition/refinement of alternative system concepts.
2. Comparative evaluation of alternative system concepts in support of selection of a single, preferred concept for development and implementation.

The following discussion reviews a number of key considerations, including applicability of thresholds and standards in support of these evaluation activities.

3.1.1 Corridor Definition

Defining one or more potential transportation corridors is fundamentally a qualitative, judgement-driven process, supported to a limited extent by quantitative analysis at the sketch-planning level. The following sequence of activities is common:

Initial Corridor Definition

1. Define conceptual guideway (horizontal) alignments based upon existing employment centers, major activity centers, and existing right-of-way "envelopes" such as freight rail lines, freeways, arterial streets, or other utility easements.
2. Make initial assumptions regarding vertical alignment (need for and extent of grade separation) and fixed guideway technology.
3. Locate station zones in areas of greatest activity consistent with approximate one-mile spacing and acceptable siting environments.
4. Identify one or more potential locations for vehicle maintenance facilities and storage yards.

Conceptual Service Plan

1. Define a conceptual service plan and estimate ridership via use of the regional travel demand model.
2. Estimate capital costs (construction and right-of-way) based on linear miles of alignment, classified by vertical placement (at-grade, exclusive ROW, at-grade in street, subway or aerial).
3. Develop a conceptual funding strategy.

The corridor definition process should result in at least one corridor which meets the following general standards:

- The corridor should be between 15 and 25 miles in length, and include the central business district (CBD) or the largest employment concentration in the region.
- Average daily weekday ridership should be, as a minimum, approximately 20,000.

Priority Corridor Selection

As part of the "alternatives analysis" process, the Federal Transit Administration (FTA) has traditionally employed rather general criteria for use in defining an initial "priority" corridor.

1. The corridor currently has a minimum of 15,000 daily transit riders; and
2. The annualized cost per new transit rider is not more than $10.00 (1984 dollars).

FTA has also typically specified that the priority corridor should include only one radial "spoke" anchored in the CBD. A number of local corridor definitions throughout the United States have, however, considered multiple spokes, e.g. Sacramento.

Definition of an initial starter line is dictated by common sense, e.g.: operational feasibility, inclusion of largest activity center(s), and by analyses that relate cost, effectiveness and financial capability. The following system logic typically applies:

> To the extent that (1) a segment by itself meets some minimum cost-effectiveness standard, or that it, in combination with the "base" system, meets the same cost-effectiveness standard and (2) the total cost (including the segment) lies within the financial capability (budget) limit, the segment should be included in the "starter line" concept. Otherwise, the segment should be excluded.

This approach differs from the FTA "Minimum Operable Segment (MOS)" concept, which is defined as the system alternative (location, length, stations, service plan) that ranks highest with respect to measurable cost-effectiveness, irrespective of financial capability, impact, or other factors.

In practice, the priority corridor should be one that:

- Yields the highest ridership
- Serves the greatest number of key activity centers
- Serves the greatest number of local jurisdictions
- Can be constructed within the maximum feasible budget for the project

3.2 Regional Travel Demand and Socioeconomic Factors

This section describes the population and employment densities of the Phoenix metropolitan area, its historic and projected growth, and the implications of the projected future growth.

Regional Population and Employment Growth

Metropolitan Phoenix's population has grown from 331,700 in 1950 to over 2,550,000 in 1995. Based on projections of continued economic strength, the region's population is projected to grow to 2,715,000 by 2000, 3,362,685 by 2010 and 4,116,600 by 2020. The plentiful supply of land for prospective development has meant that the metropolitan area has generally developed in a low density dispersed fashion with many commercial cores. Most high rise development in Phoenix has occurred along the Central Avenue urban corridor, with smaller downtown and commercial centers in the neighboring communities.

Figures 3-1 and **3-2** display the locations of forecast growth in housing and employment based on current adopted plans. New households will tend to concentrate most heavily on the periphery of the metropolitan region while employment increases will be more evenly dispersed throughout the Valley, with a major concentration in central Phoenix. **Figures 3-3** and **3-4** display the resulting densities in housing and employment, respectively for the year 2020. The dispersed growth pattern and the distances between housing and employment will contribute to a growth of travel at a faster rate than population and employment.

Figure 3-1
Housing Growth: 1995 to 2020

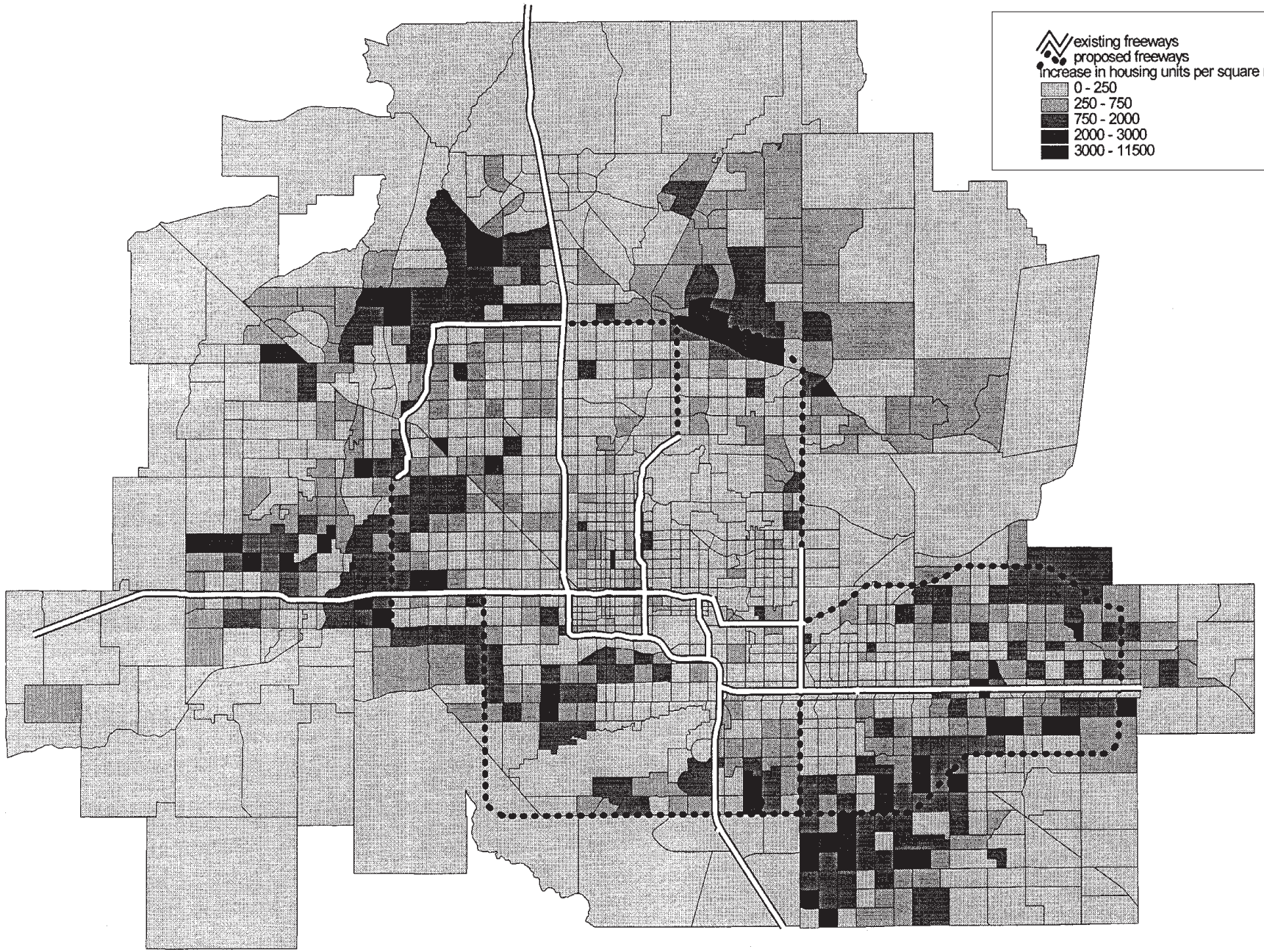


Figure 3-2
Employment Growth: 1995 to 2020

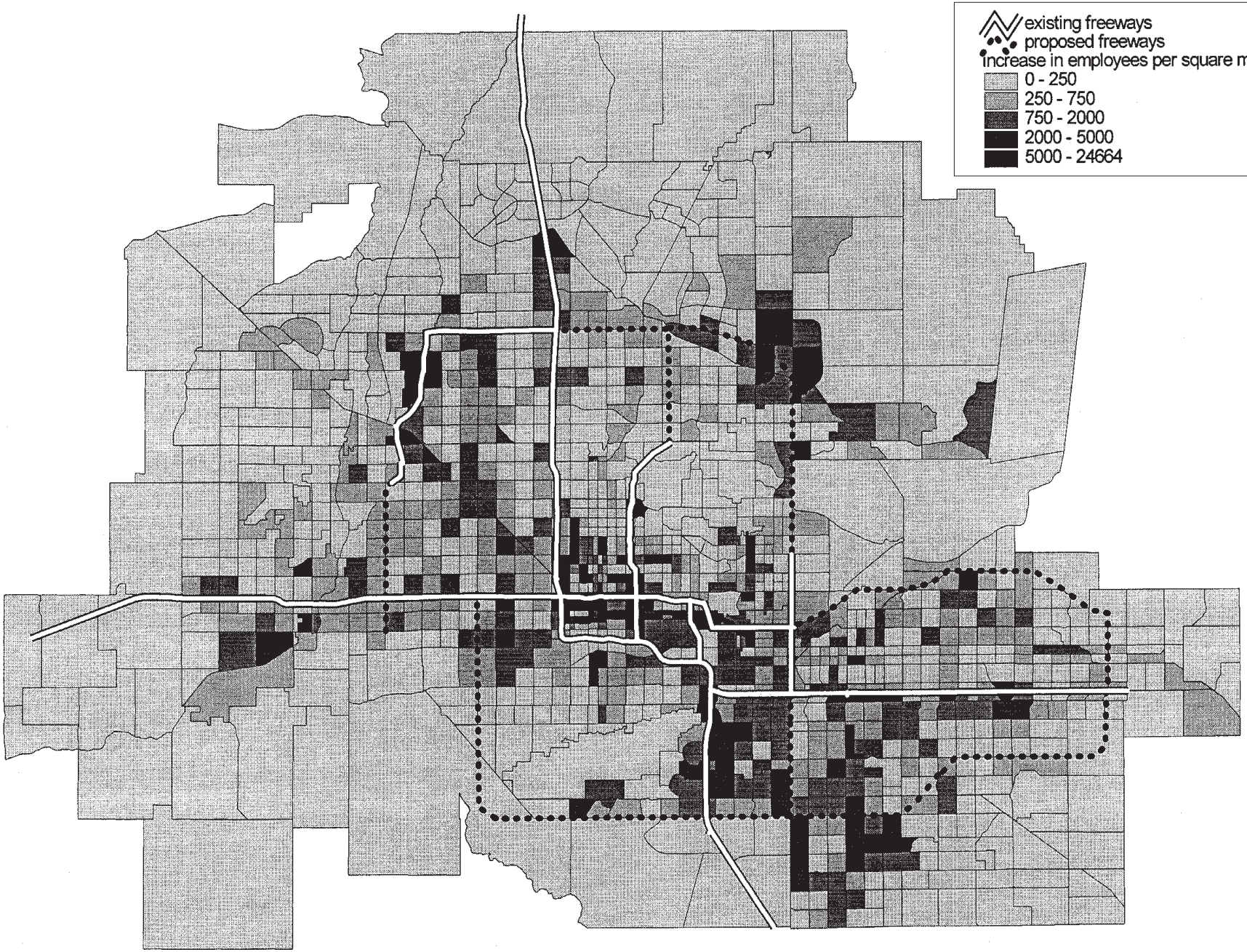


Figure 3-3
Year 2020 Housing Density

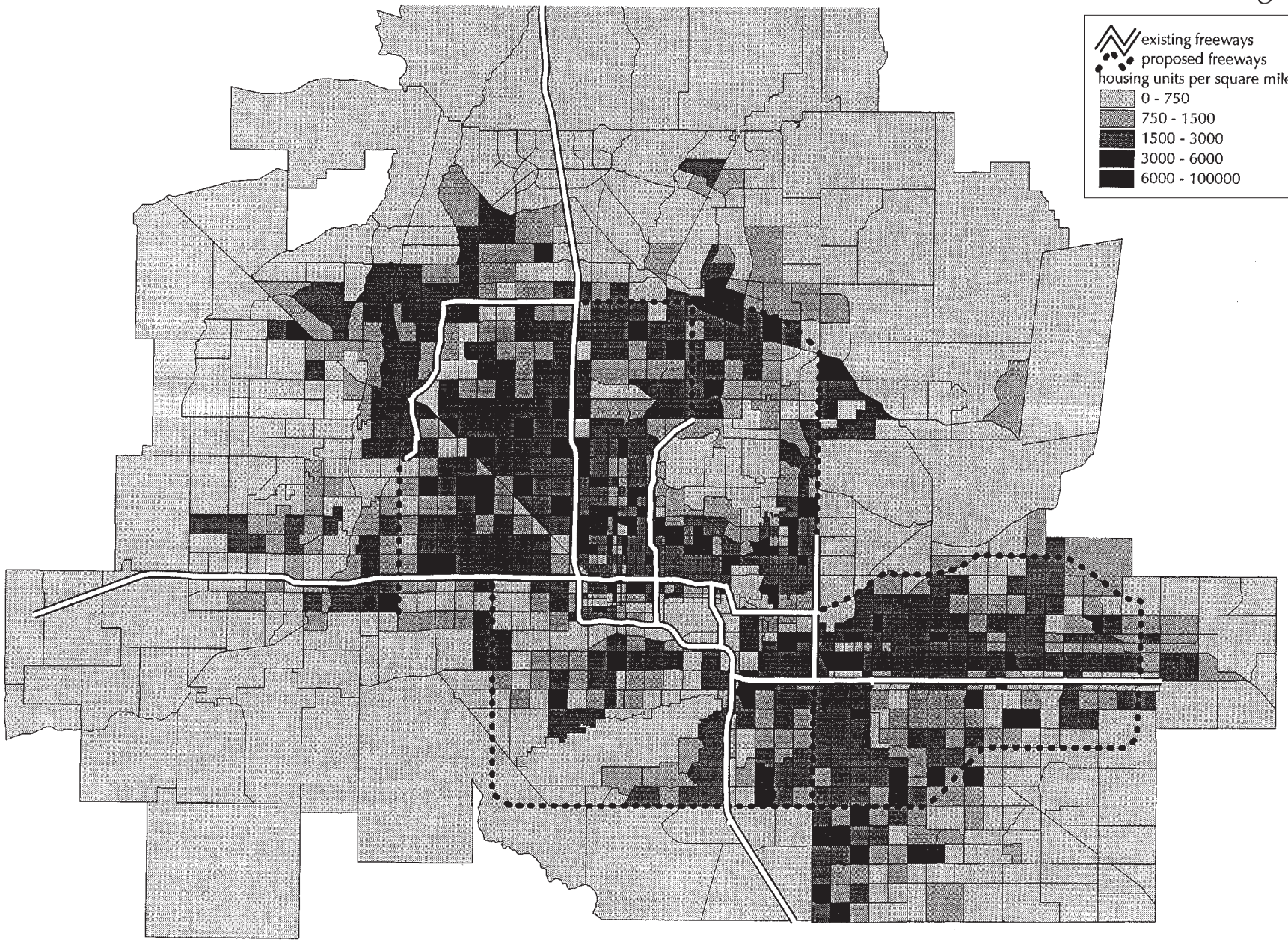
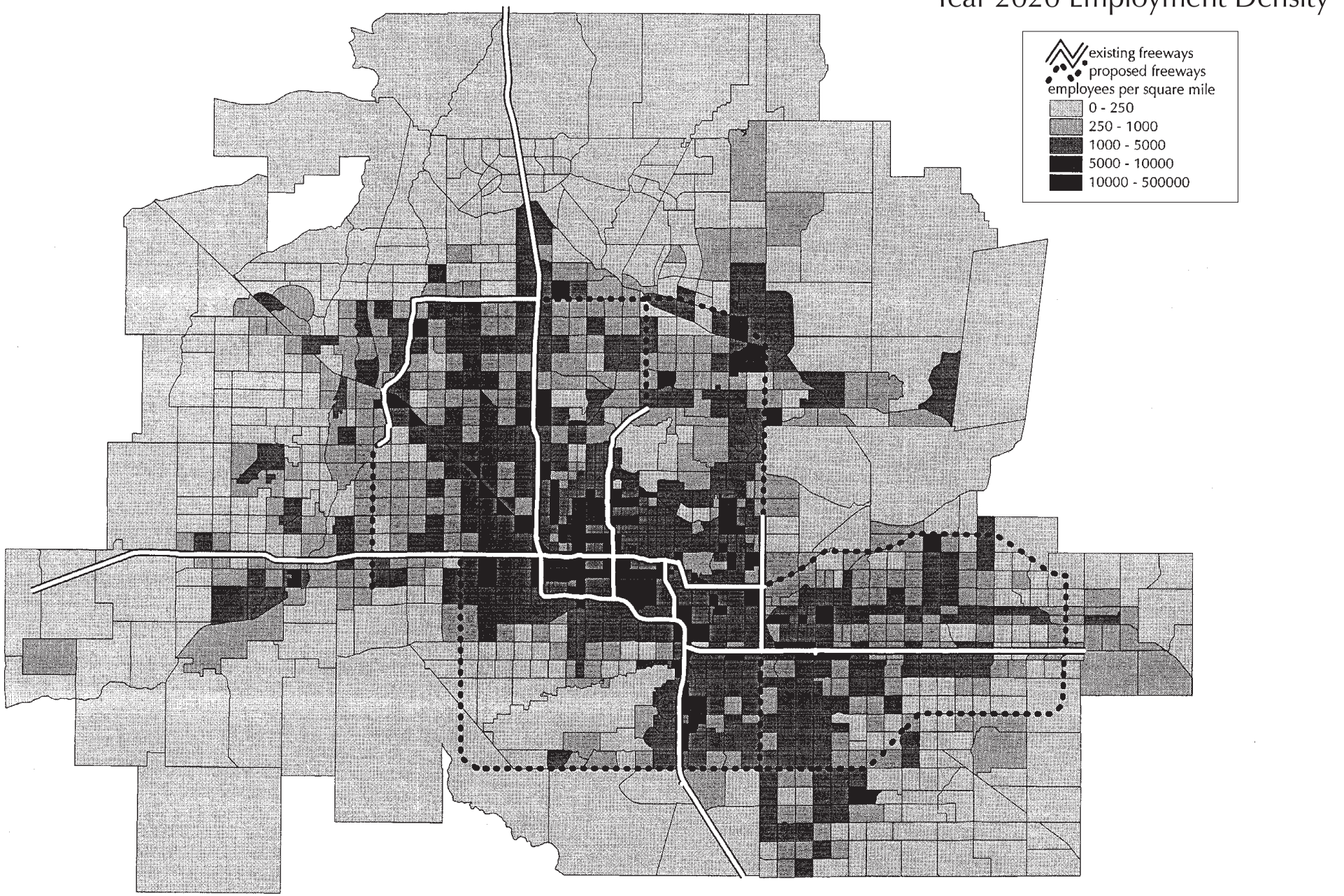


Figure 3-4
Year 2020 Employment Density



Regional Travel Demands

The Maricopa Association of Governments (MAG) Long Range Transportation Plan (LRTP), most recently updated in 1998, addresses regional needs for all transportation modes for a twenty year planning horizon. The LRTP considers forecasts of regional population and employment growth, and uses travel simulation models to anticipate needed improvements to the regional roadway and transit systems. Based upon the projected growth of 70 percent in population, the MAG Regional Travel Demand Model forecasts an 80 percent increase in regional travel for the year 2017 .

Forecast trip ends closely parallel the locations of major activity, residential and employment centers. **Figures 3-5** and **3-6** display work and non-work person trip ends, respectively, for the year 2020. **Figure 3-7** displays the density of forecast transit trip ends for the year 2020.

The growth and spread of regional travel is also visually represented by the "desire lines of travel" as shown in **Figure 3-8** for the year 2020. This graphic indicates the major traffic flows resulting from Valley-wide, intercity trip making. **Figure 3-9** displays desire lines of travel for existing (1995) bus transit passengers only. Comparison of the two plots indicates the degree to which bus trips concentrate along corridors with the most transit service and the limited extent to which current bus service is oriented to serve overall regional travel demands in the future.

Impacts and Implications

Because of the large forecast VMT increase, regional traffic congestion will persist in 2020, despite the LRTP's assumption of major transportation improvements, including a 69 percent increase in freeway and expressway lane miles and a 57 percent increase in surface street miles. Without these planned improvements, average travel speeds would decline 11 miles per hour and the congested proportion of peak hour regional travel would triple.

In light of projected 2020 traffic increases, levels of congestion, and the environmental impacts associated with continued reliance upon the automobile, implementation of a fixed guideway transit system offers opportunities to enhance regional mobility and support alternative regional development patterns.

3.3 Travel Corridor Evaluations

Fixed guideway transit plays its most important role in heavily traveled corridors where large numbers of trips between similar origins and destinations are made. At the same time, the highest volume corridors will generally have the greatest congestion problems and the most need for additional transportation capacity. The initial travel corridor screening process was based upon these more general considerations of regional travel. **Figure 3-10** displays the regional travel corridor screening methodology.

The first step in the evaluation procedure involved a quantitative analysis of the MAG Travel Demand Model data output depicting projected 2020 travel patterns and roadway network performance. A screenline analysis was conducted by corridor segment for the purpose of identifying travel volumes, corridor capacity and resulting levels of congestion.Corridor

Figure 3-5
Year 2020 Work Trip Ends

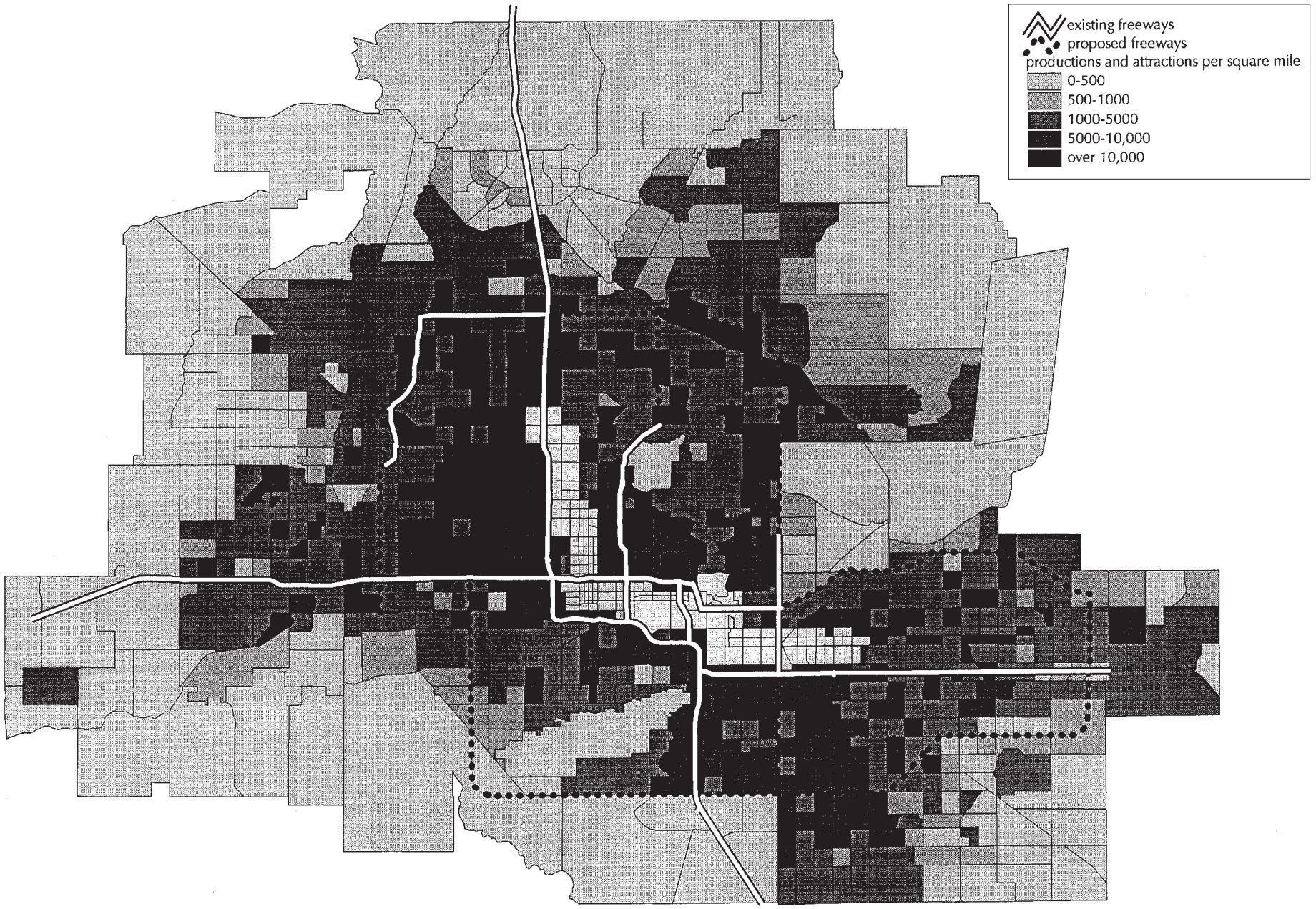


Figure 3-6
Year 2020 Non-Work Trip Ends

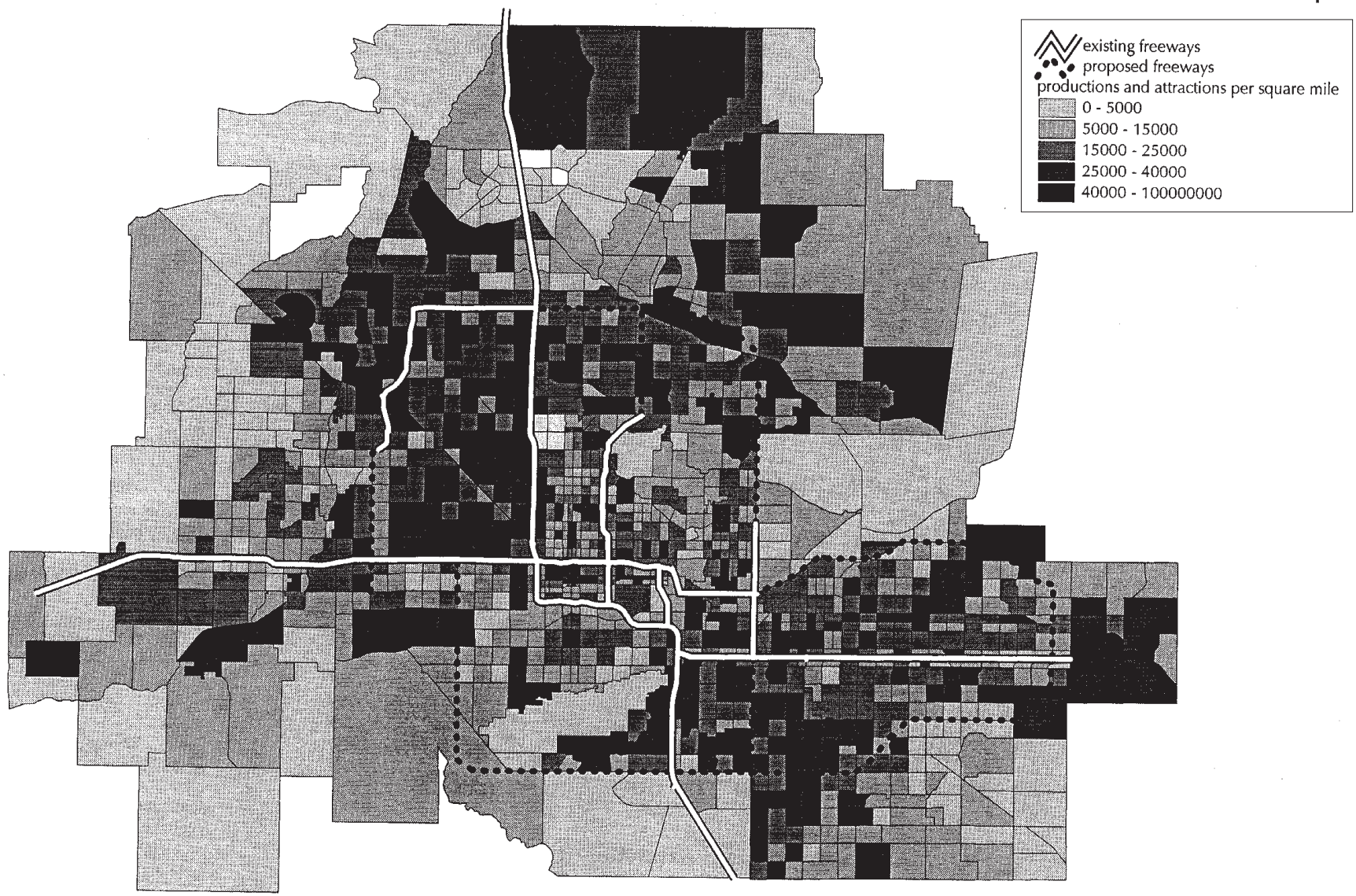


Figure 3-7

Year 2020 Forecast Daily Transit Trips

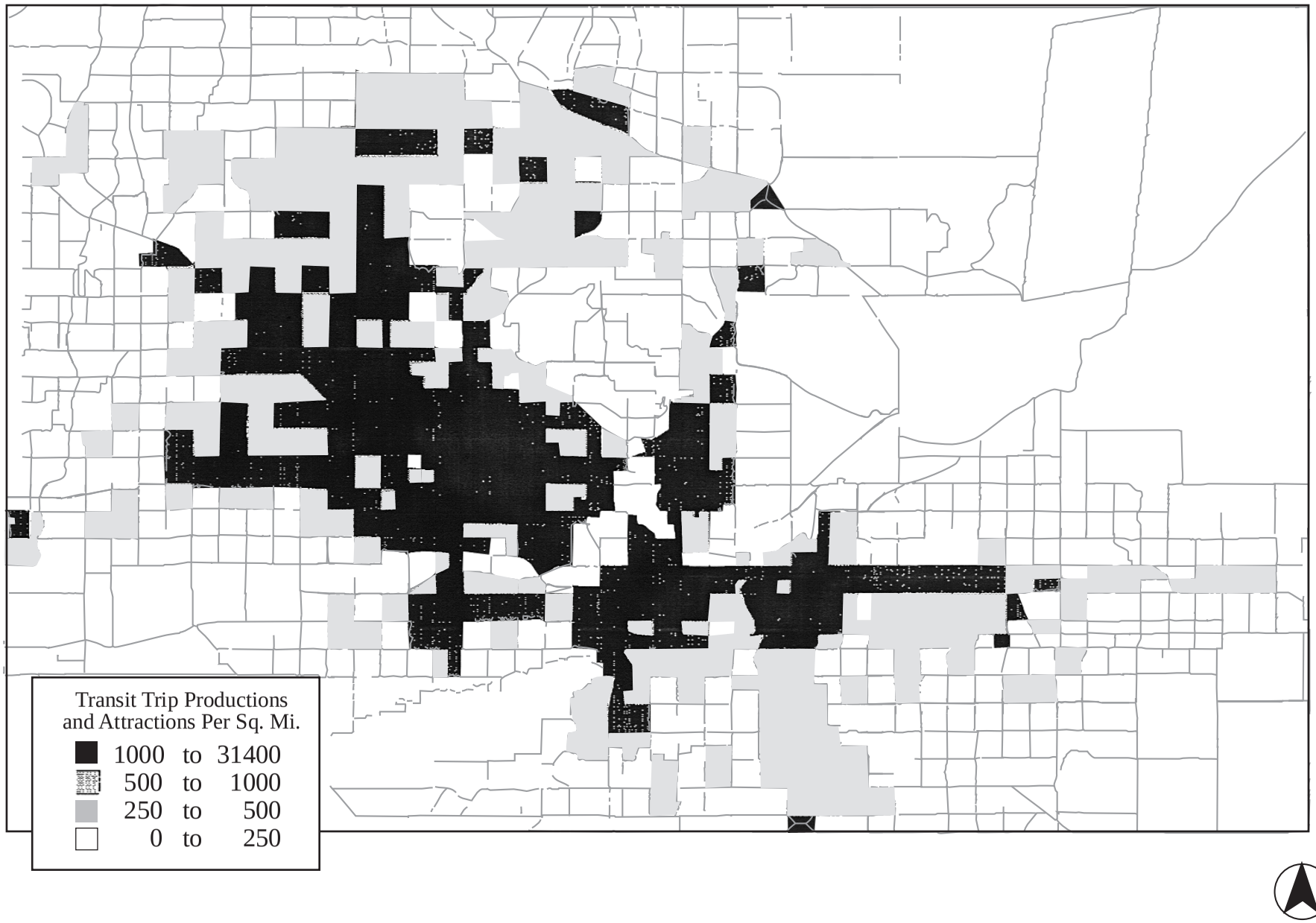


Figure 3-8

Year 2020 Daily Vehicle Desired Lines of Travel

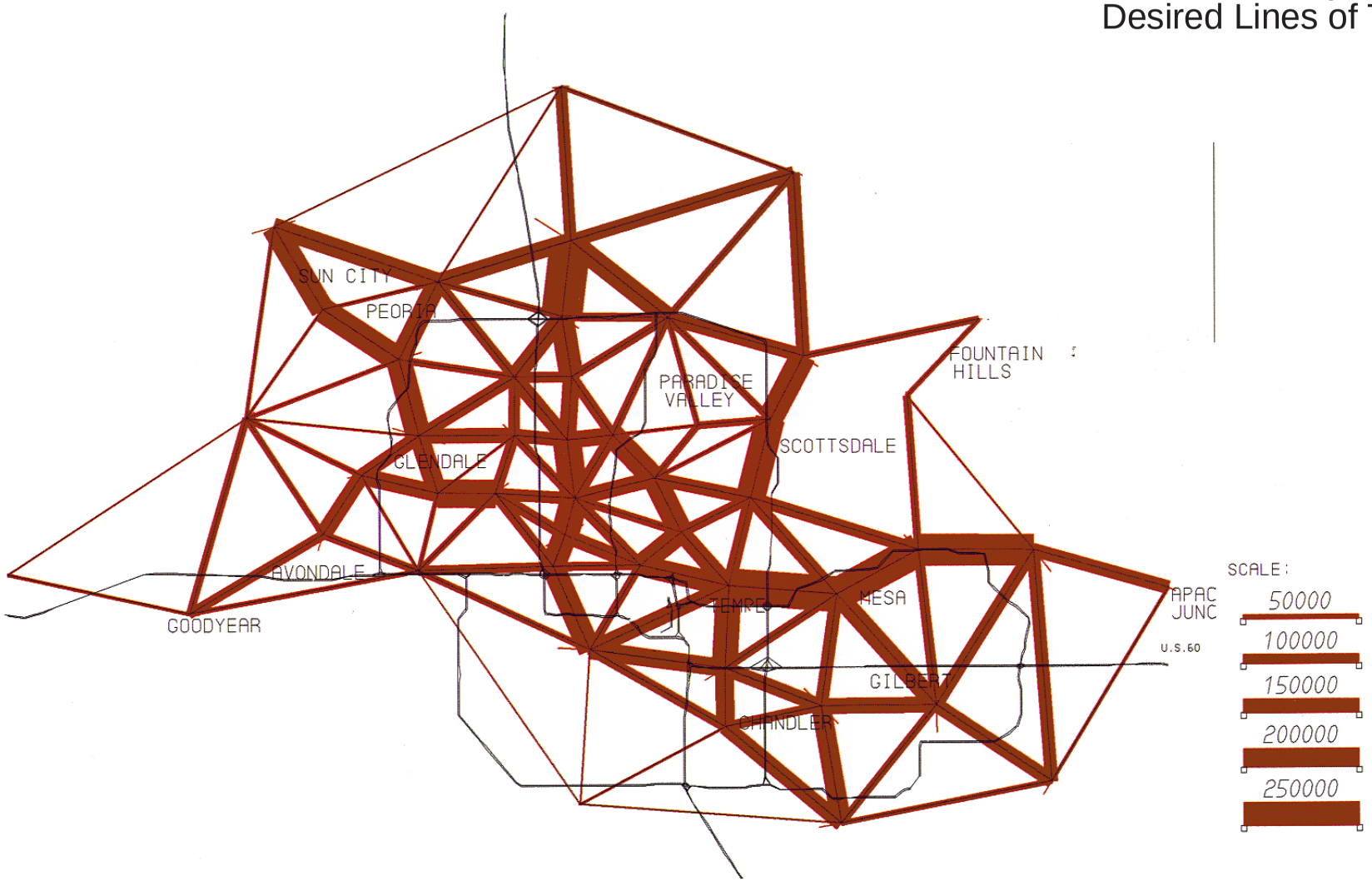


Figure 3-9

Year 2020 Daily Bus Passenger Desired Lines of Travel

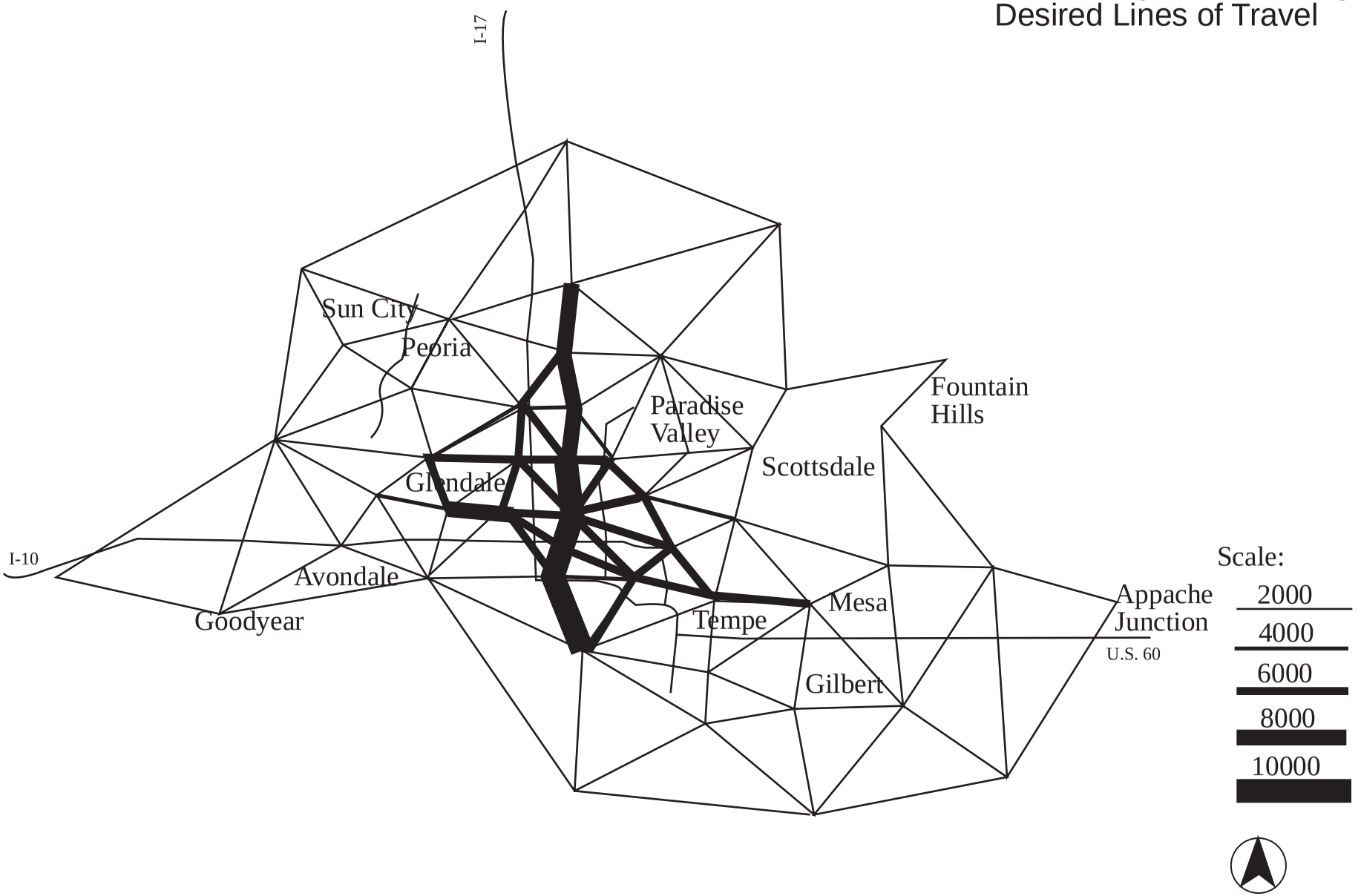
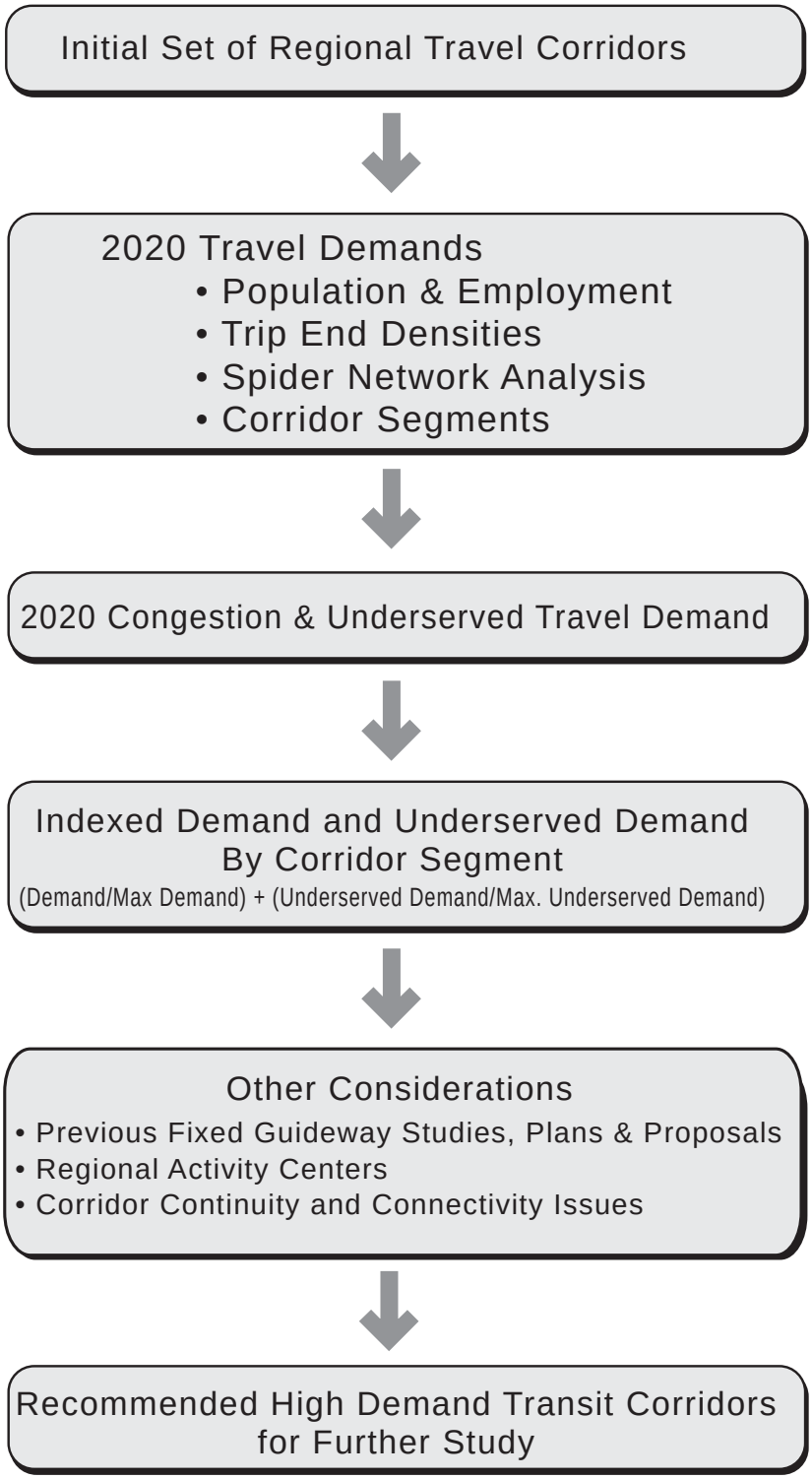


Figure 3.10
High Demand Transit
Corridor Identification Methodology



segments were then ranked by quartiles (25, 50, 75 and 100%) based upon magnitude of travel demand and congestion. A number of subsequent considerations were then utilized to define a set of regional travel corridors for further evaluation as fixed guideway corridors.

Candidate Regional Travel Corridors

An initial set of 18 regional travel corridors were identified based on review of regional travel patterns and previous fixed guideway studies. **Figure 3-11** displays the initial candidate regional travel corridors. A corridor was broadly defined as an area 1 to 2 miles in width and varying in length from 5 to 30 miles. The regional travel corridors are generally centered on existing or proposed major transportation facilities, and do not necessarily propose a specific location for a fixed guideway transit line. Generally, a number of options will be available within each corridor for location of a fixed guideway alignment.

Person Trip Demand

Within each corridor, corridor segments were identified to facilitate the travel demand analyses. A corridor segment was generally defined as a section of corridor between that corridor's termination and the crossing of another corridor, or as a section between two corridor crossings.

Year 2020 person trip demand by corridor segment is listed in **Table 3.1**. This data was obtained from an unconstrained MAG model run in which the capacities of all facilities in the regional roadway network model were equal. This allowed an analysis of demand based on the most direct route of travel, not constrained by capacity or congestion. **Figure 3-12** displays a band width summary of unconstrained demand on the regional roadway network. Grand Avenue was not included in the regional roadway network due to its diagonal orientation

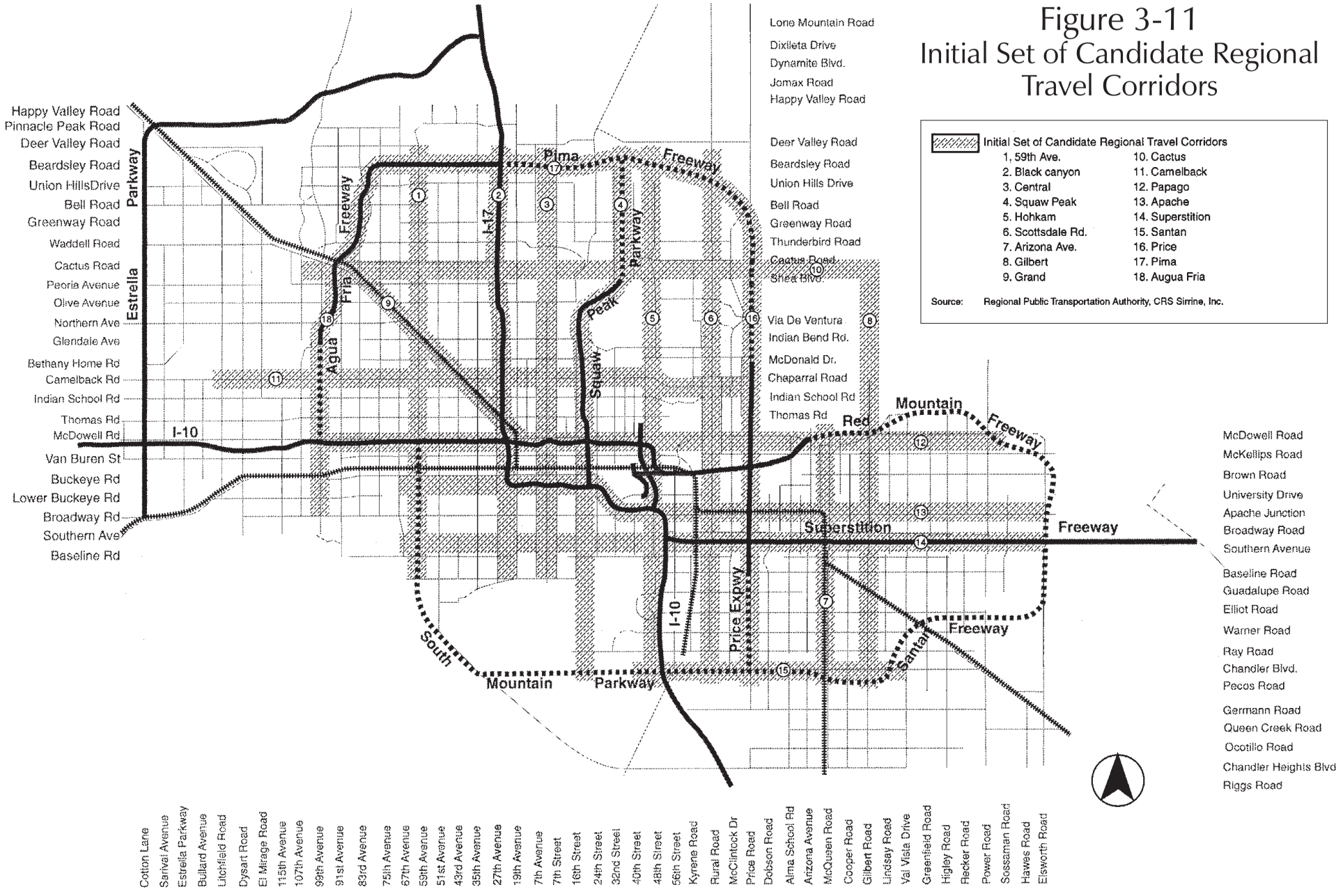
Figure 3-13 displays the quartile ranking of corridor segments based on level of person trip demand. In general, the highest quartile segments lie in the most central areas and along freeway segments. Notable non-freeway segments with high person trip demand are the Central Avenue and Camelback Road Corridors in the central Phoenix/downtown area and the Broadway and McDowell Road Corridors to the east of the downtown area. Lowest demand was noted in corridors along the perimeter of the metropolitan area such as the Pima and Agua Fria Freeways and the Gilbert Road Corridor.

Corridor Congestion/Underserved Demand

Year 2020 underserved demand was identified by corridor segment using data from a capacity restrained MAG model run. Underserved demand was identified as demand in excess of the reasonable capacity of a roadway. The quantity of underserved demand on congested segments was defined as that portion of demand exceeding a Volume / Capacity ratio (V/C) of 0.9. Undeserved demand is summarized by Corridor segment in **Appendix A**.

Figure 3-14 displays the quartile ranking based upon the percent of underserved demand for each corridor segment. Only segments that were found to have underserved demand greater than zero were included in this ranking with all other segments displayed as having *No Underserved Demand.*

Figure 3-11
Initial Set of Candidate Regional Travel Corridors



Source: Regional Public Transportation Authority, CRS Sirrine, Inc.

Figure 3-12
Year 2020 Daily Unconstrained Travel Demands

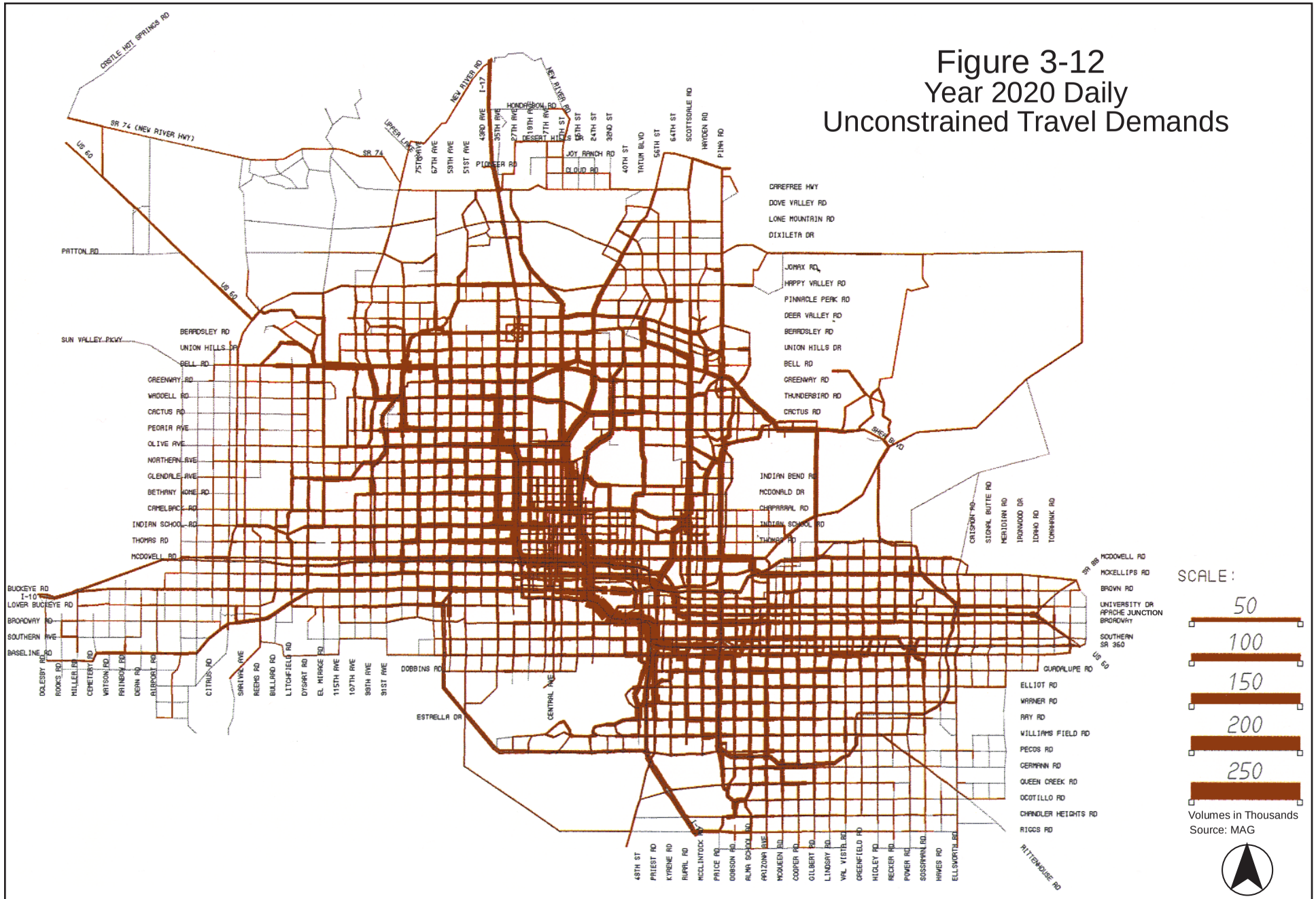


Figure 3-13
High Demand Corridors - 2020 Person Trip Demand

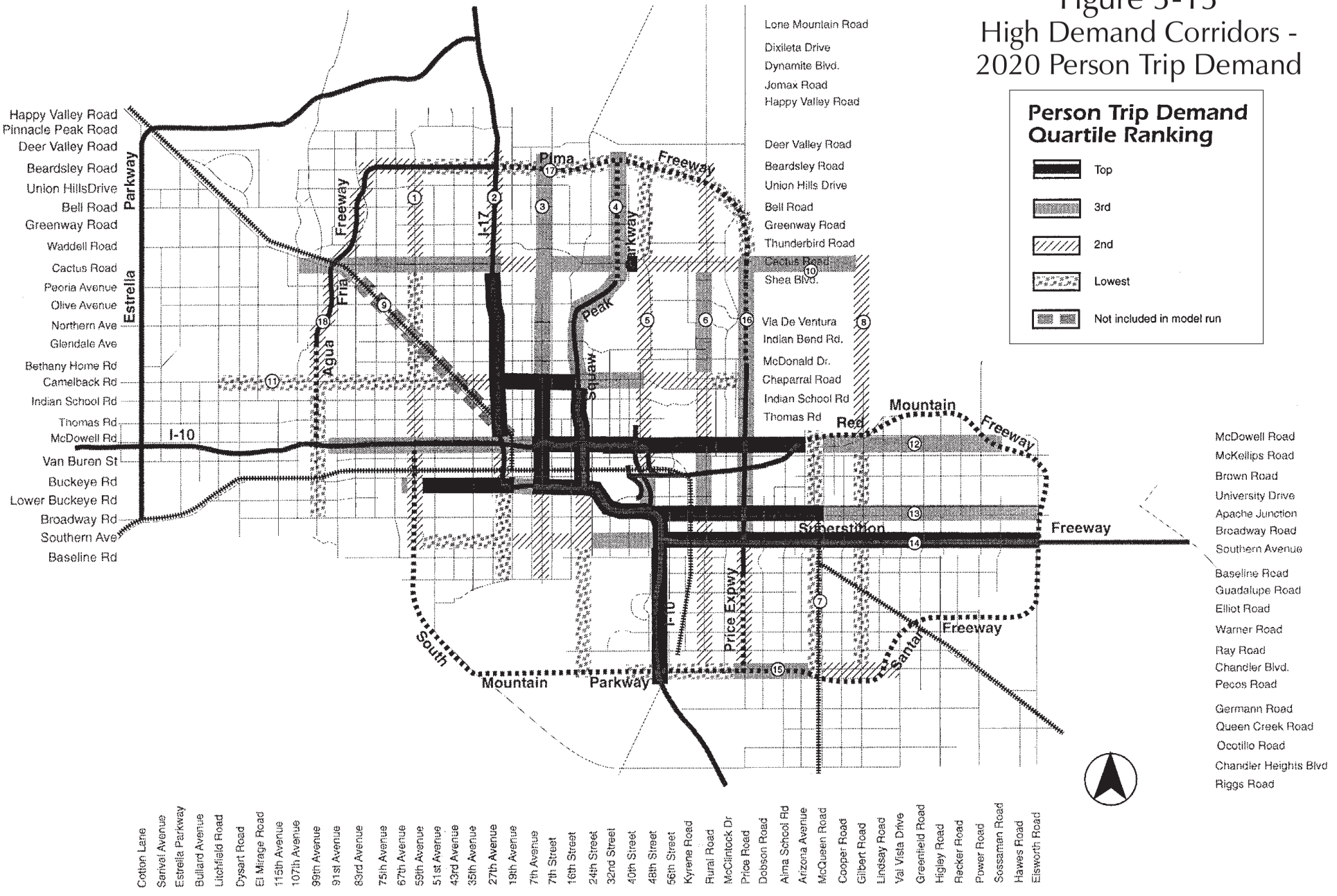
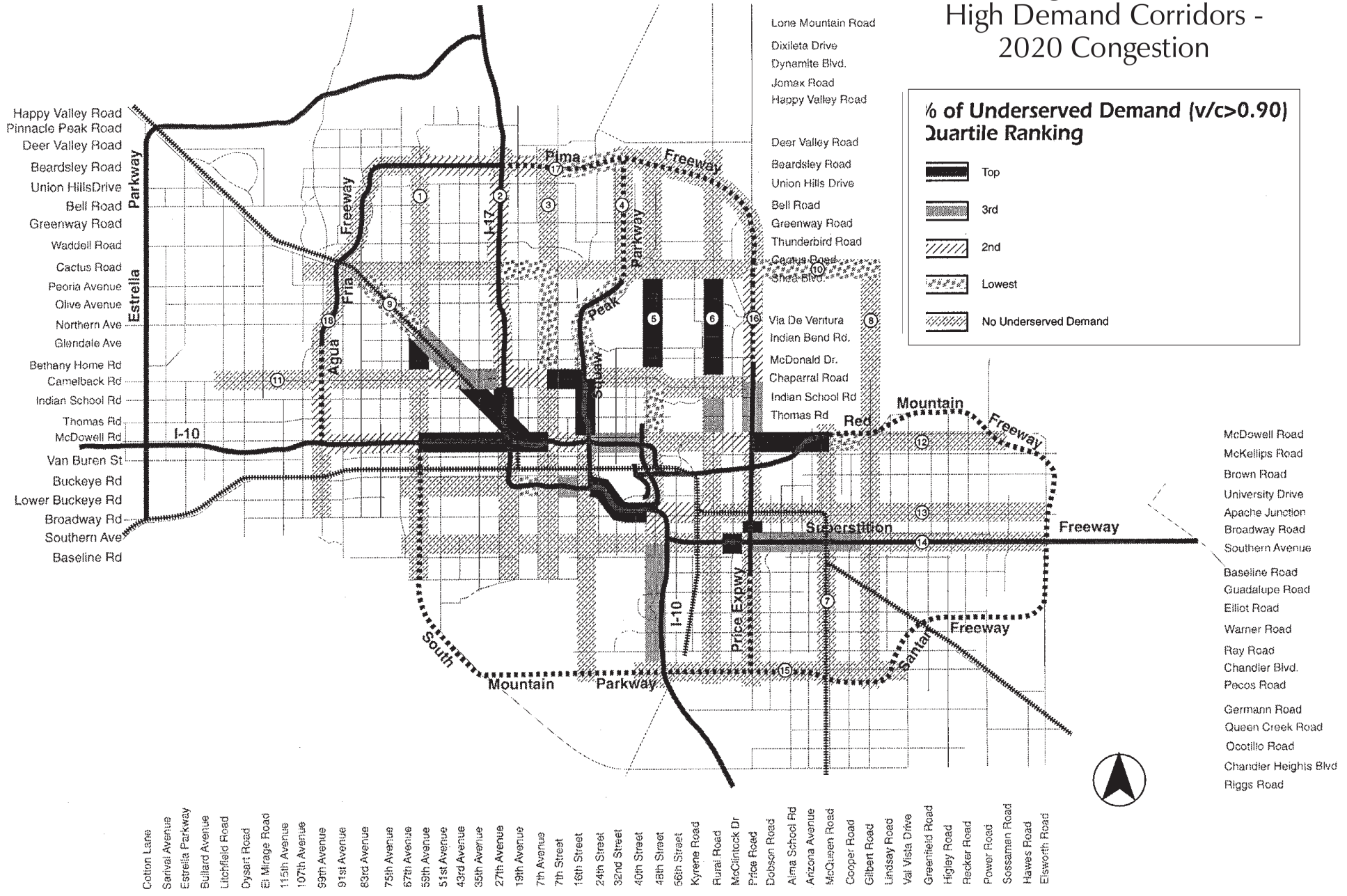


Figure 3-14
High Demand Corridors - 2020 Congestion



The highest percentages of underserved demand are associated with freeway corridors in the central and eastern portions of the city, as well as in the Scottsdale area. The corridors with the most continuous segments exhibiting underserved demand include Corridors 12, 13, and 14 which contain I-10, the Superstition Freeway and a portion of the Red Mountain Freeway. However, some single segments, such as a segment of the Scottsdale Road Corridor in the vicinity of Scottsdale, which have the highest levels of underserved demand have adjacent segments exhibiting no underserved demand.

Similar to person trip demand, the lowest levels of underserved demand occur mostly in the outer portions of the metropolitan area. However, low levels of underserved demand are exhibited on segments of the Central Avenue and Squaw Peak Parkway corridors just north of the downtown area.

3.4 Indexed Demand and Congestion

To facilitate a direct comparison of the corridor segments based upon both levels of demand and congestion, an indexing scheme was devised as follows:

$$\frac{\text{Segment Person-Trip Demand (Unconstrained)}}{\text{Maximum Segment Person-Trip Demand (Unconstrained)}} + \frac{\text{Segment Underserved Demand}}{\text{Maximum Segment Underserved Demand}} = \text{INDEX}$$

This indexing scheme provides the ability to make relative comparisons between the corridor segments, based equally on the magnitude of corridor travel demands and levels of congestion and underserved demand. Since both ratios are based on the maximums observed, corridor segments with both high person trip demands and high underserved demands will result in high corridor indexes. **Table 3.1** provides a set of example calculations to clarify the indexing procedure.

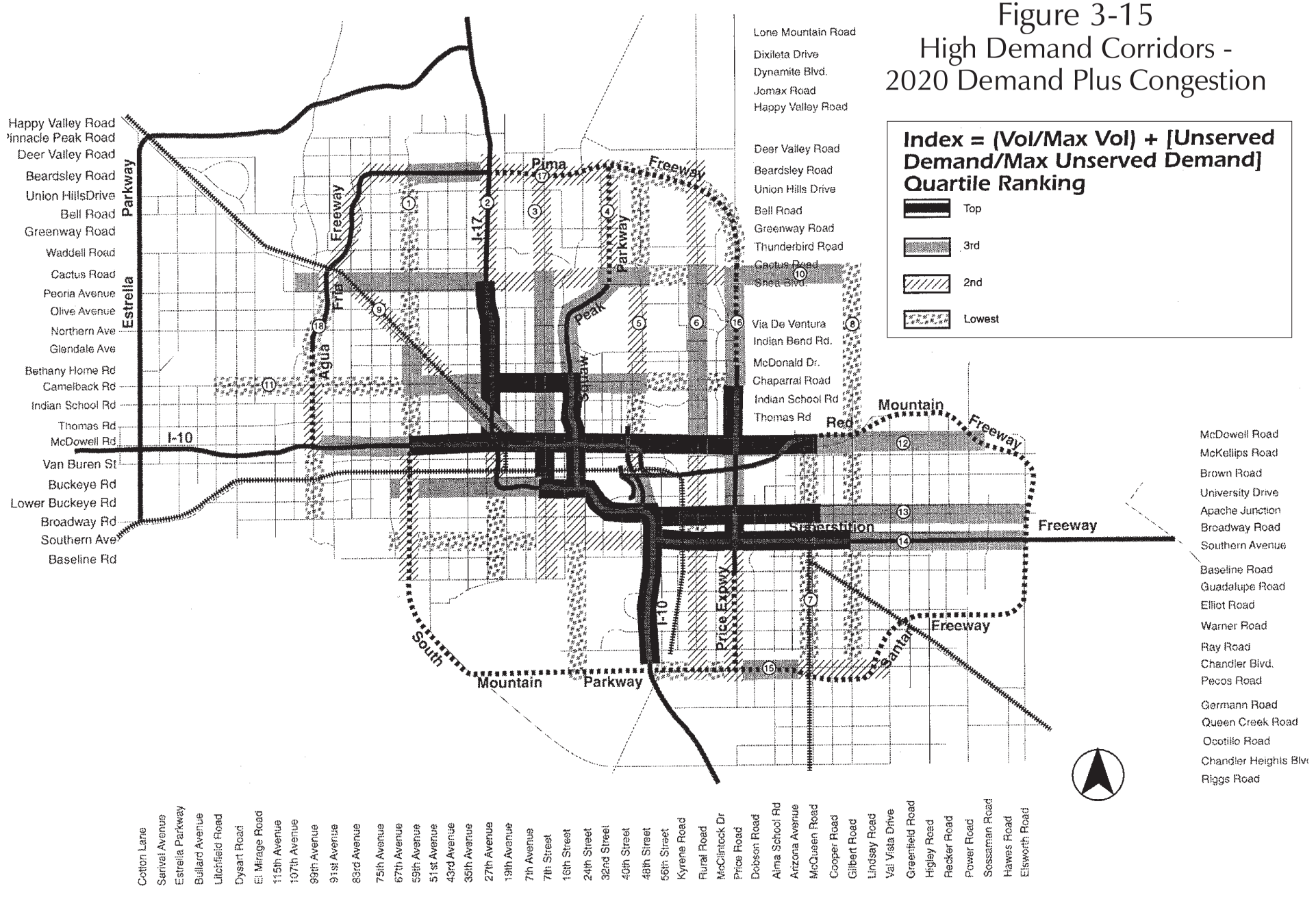
TABLE 3.1
Examples of Demand/Congestion Indexing Procedure

Corridor Number	Screen-line Number	Person Trip Demand Ratio			Under Served Demand Ratio			INDEX (1 + 2)
		ADPT*	Max ADPT	ADPT / Max ADPT (1)	Undrsrvd Demand	Max. Undrsrvd Demand	Undrsrvd Dmnd/ Max Unsvd Dmd (2)	
2	3	295,400	379,400	0.779	78,000	78,000	1.000	1.779
12	2	168,000	379,400	0.443	7,000	78,000	0.090	0.533
14	8	68,600	379,400	0.181	0	78,000	0.000	0.181

*Note: Year 2020 Average Daily Person Trips Source: BRW, Inc.; November, 1996

The resulting corridor segment indexes were also ranked via quartiles as illustrated in **Figure 3-15**.

Figure 3-15
High Demand Corridors - 2020 Demand Plus Congestion

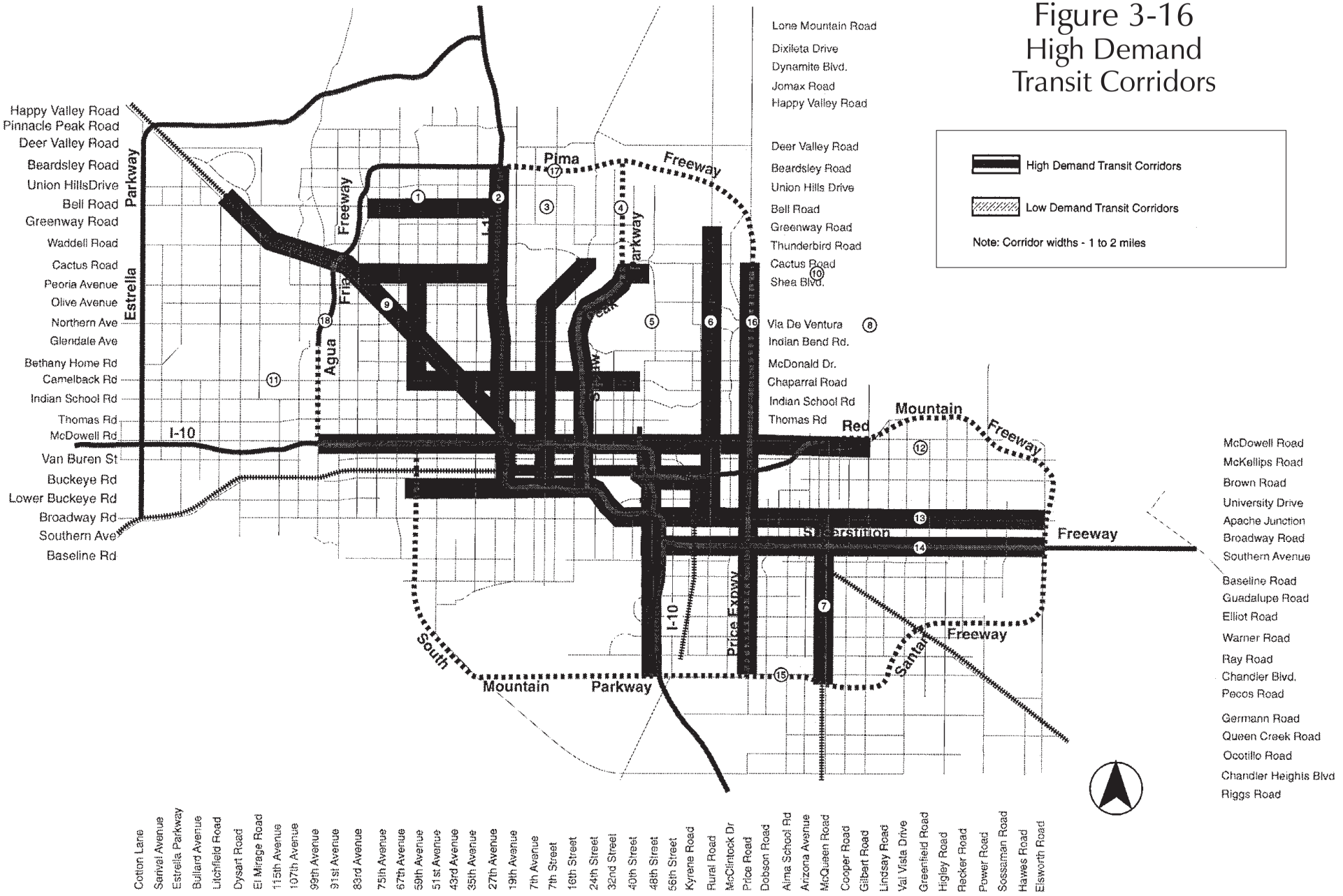


In general, freeway corridors extending out from the central metropolitan area have the highest indices. Other heavily traveled and congested corridors are found along the Camelback Road and McDowell Road Corridors, as well as the Broadway Road Corridor, which is coincident with an existing rail alignment. Not unexpectedly, the lowest indices are observed around the perimeter of the metropolitan area.

3.5 High Demand Transit Corridors

Figure 3-16 displays the identified high demand transit corridors. Key considerations included corridor travel demands and level of congestion and underserved demand. Previously studied transit corridors and the need to provide for continuity and connectivity between high demand transit corridor were also key considerations.

Figure 3-16
High Demand Transit Corridors



4.0 Transit Technologies and Fixed Guideway System Options

An initial set of transit technologies and fixed guideway system options were modeled and reviewed by a panel of national experts. Based upon this review, in March 1998 the MAG Transportation Review Committee, RPTA, and VMOS approved the following fixed guideway system options for analysis:

Base Case (current MAG Long Range Plan)

Express Bus/Busway

Commuter Rail

Light Rail

Automated Light Rail

Light Rail Plus Commuter Rail

Light Rail Plus Express Bus

The following sections provide a detailed description of each of the fixed guideway system options.

4.1 Base Case

It has been commonly understood that a major improvement to the bus system in the MAG area is needed before proceeding with development of a regional Fixed Guideway System. This study (current MAG Long Range Plan) has assumed that expanded bus service would be common to all study options.

The MAG Long Range Transportation Plan Bus System component served as the Base Case. This system was initially developed by a Citizen Advisory Group and approved by the RPTA Board in 1993. This plan has been periodically adjusted but the basic concept remains the same. The Plan includes regional wide improvements in bus service. New service is provided to outlying areas and the frequency of service is increased in central areas. Overall bus service is doubled and then increased an additional 36% to accommodate regional growth.

4.2 Express Bus/Busway

This option addresses the needs of peak period, longer distance commuters by focusing service on collecting passengers in outlying areas and providing express access to activity centers. The Express Bus/Busway option included a five-fold increase in revenue miles of express bus service above planned conditions (see **Figure 4-1**). This option also included 22 new on-line bus stations, numerous new park-and-ride lots, 48 lane miles of new HOV lanes above planned

Figure 4-1
Express Bus/ Busway Concept

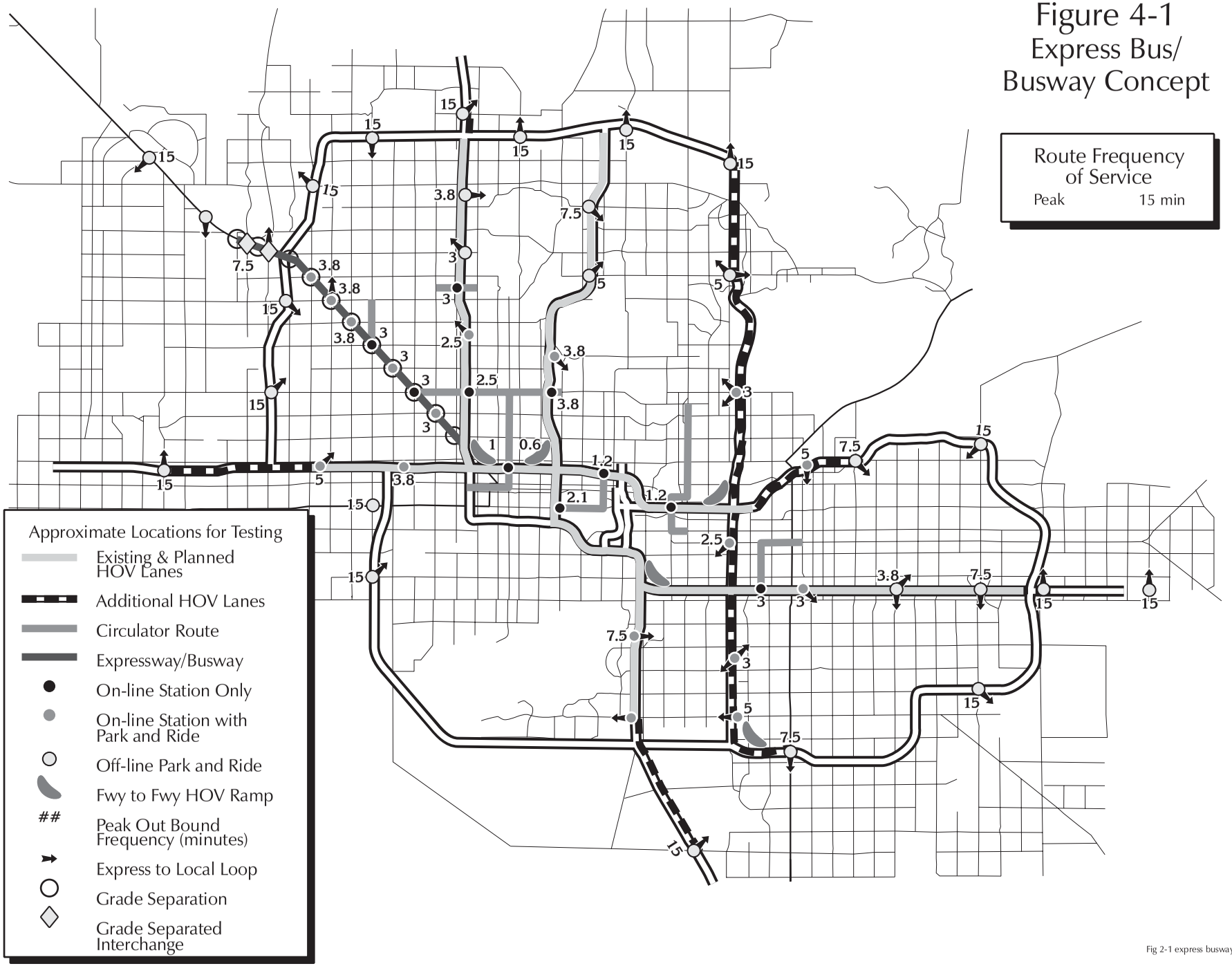


Fig 2-1 express busway.cdr

conditions and upgrading of Grand Avenue to a grade-separated expressway and busway concept with HOV lanes and bus stations every mile.

In the operating plan, express buses circulate in neighborhoods in outlying areas and then travel in an express mode to the Deck Park. Circulation buses provide connections from express bus service to activity centers. The headway on routes is 15 minutes in the peak period and 30 minutes in the off-peak period.

4.3 Commuter Rail

This option provides commuter rail service on all major rail links in the Valley (see **Figure 4-2**). This option would service longer distance trips by suburban commuters who work in central areas. Because stops are further apart, transfers between the commuter rail and local bus are required in central areas, while auto and local bus access is needed in outlying areas.

Station spacing would be typical of commuter rail service (greater than every two miles). Service would be 30 minute frequencies. As routes combine, service would be more frequent in some central areas, with double tracking required on most routes. Top speeds on this system could approach 65 miles per hour given wide station spacing and typical railroad access controls.

4.4 Light Rail

The option included a 68 mile at-grade light rail transit system (see **Figure 4-3**). Station spacing is usually every mile except in downtown areas where the spacing is one-half mile. Most stations have park-and-ride facilities except in the downtown areas. This option provides high capacity transit service directly to activity centers. However, because it is at-grade and has frequent stops, the overall speed is limited.

In rail corridors, speeds could approach 65 miles per hour; but in most areas, street conflicts would limit top speeds to 40 miles per hour. Average speeds are typically much lower due to station stops. The frequency of weekday service varies from every five minutes in the peak period in central areas to every 20 minutes in off-peak periods in outlying areas. The option includes 12 miles of support circulation routes, with some reconfiguration of local bus services to support light rail stations. Parallel bus routes have also been eliminated.

4.5 Automated Guideway

The proposed system is 31 miles long and is similar to a fully grade-separated light rail concept (see **Figure 4-4**). Stations are usually every mile except in downtown areas where spacing is usually two per mile. Most stations have parking areas, except in downtown areas. Because it is grade-separated, the overall speed is improved over the at-grade light rail option. Top speeds could approach 65 miles per hour where stations are widely spaced, but the average speeds are much less due to station stops. The frequency of service is five minutes in the peak and ten minutes in the off-peak. Eight miles of downtown circulators are included to facilitate access in central areas.

Figure 4-2
Commuter
Rail Concept

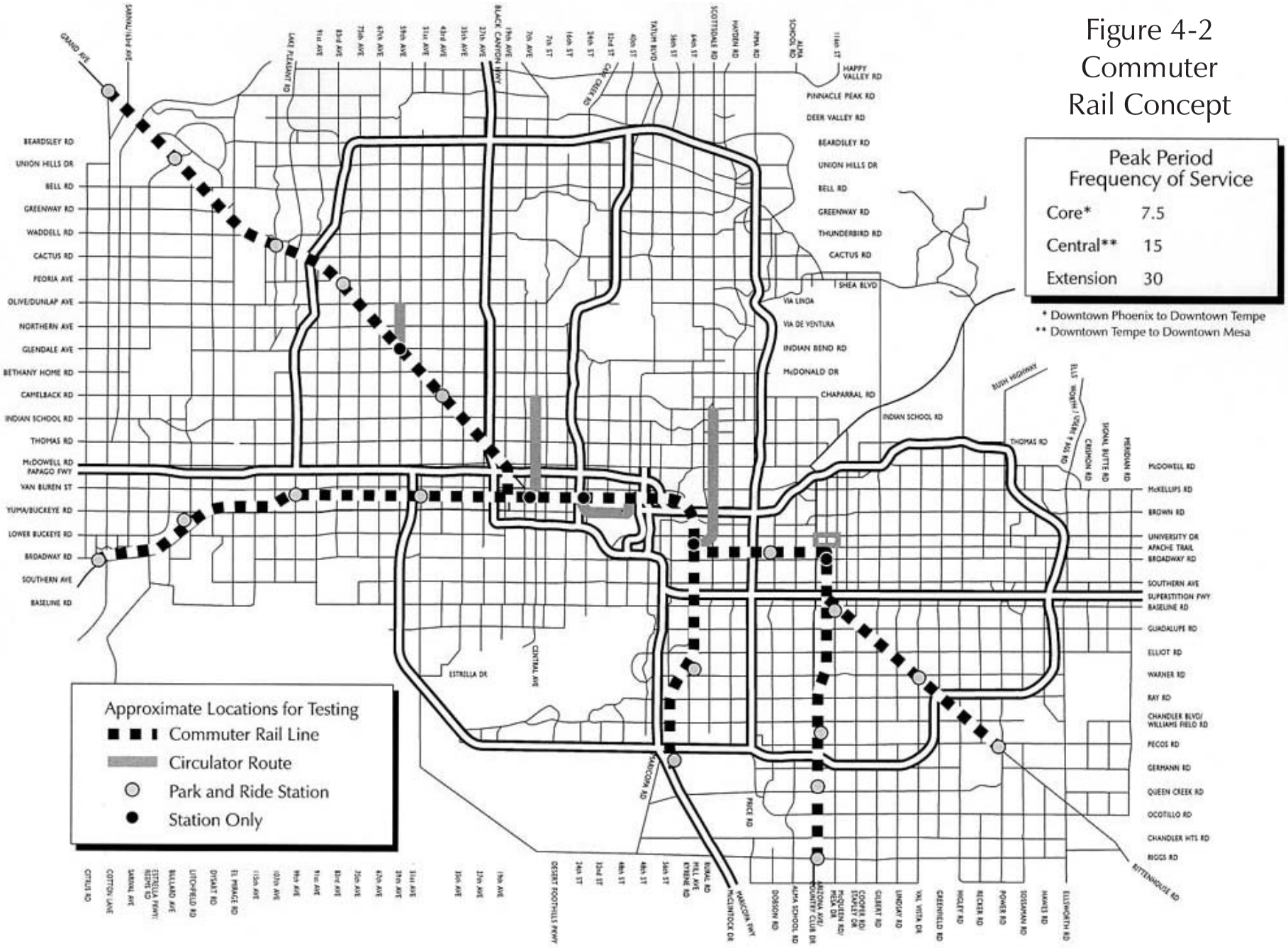
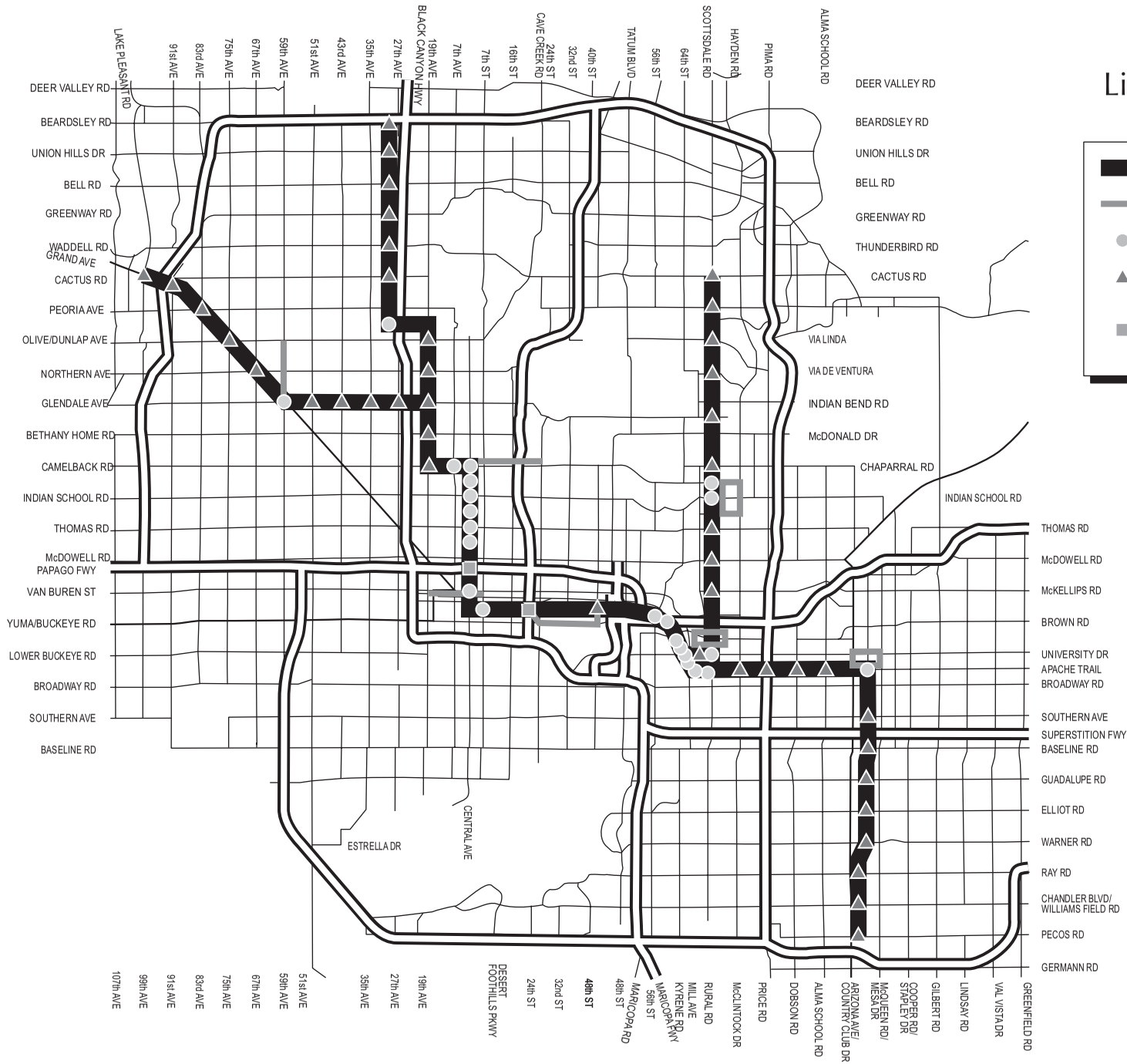


Fig 2-2 commuter rail.cdr

Figure 4-3
At-Grade Light Rail Concept



Light Rail Line

Circulator Route

Rail Station*

Station with Park and Ride*

Station with Express Bus Terminal

* All rail stations will have local bus connections

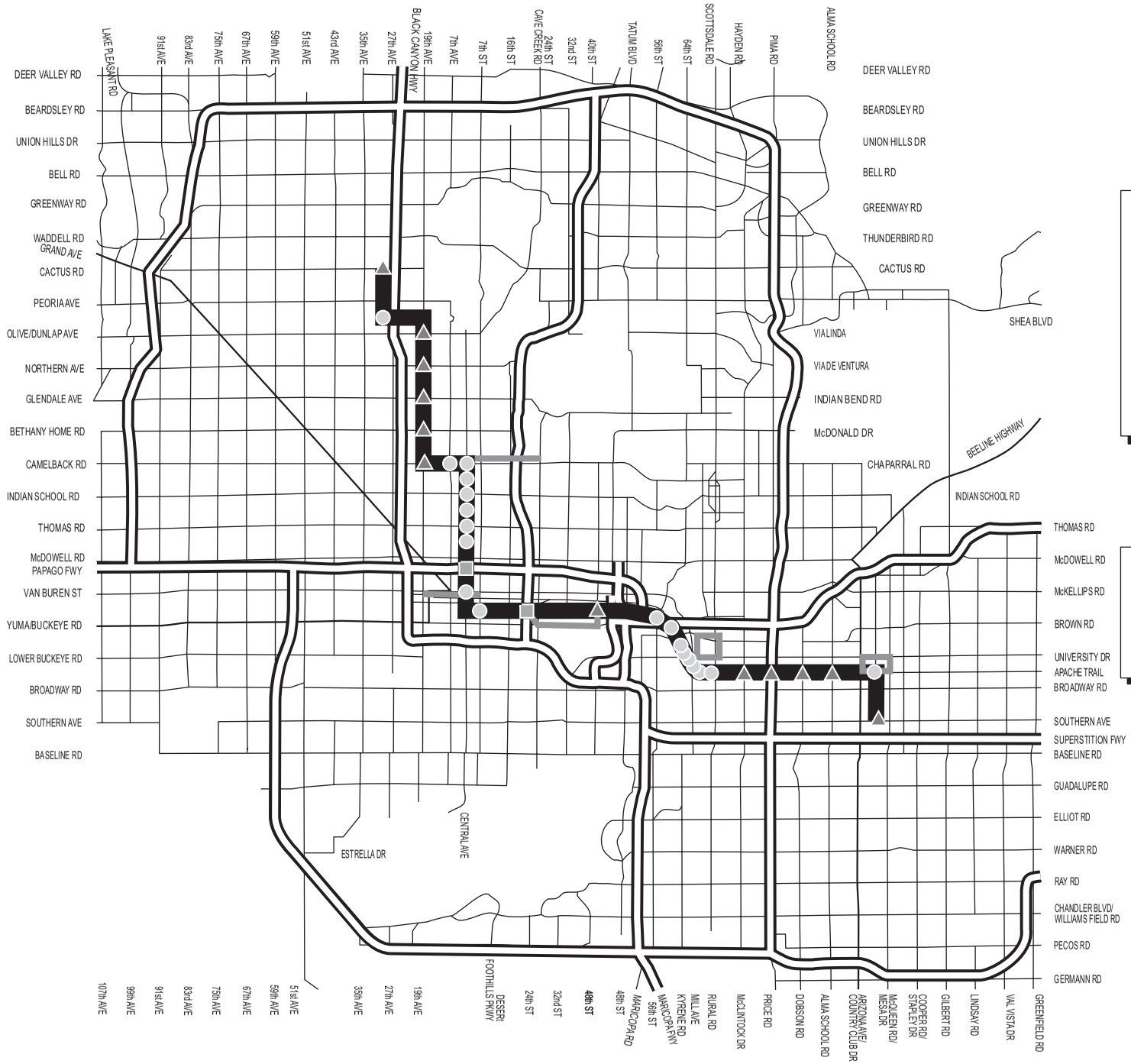
Frequency of Service

	Peak	Off Peak
Central*	5	10
Extension	10	20

* Glendale and 19th Avenues to University and S.P. Line

Fig 2-3 at grade rail.cdr

Figure 4-4
Automated Guideway Concept



Light Rail Line

Circulator Route

Rail Station*

Station with Park and Ride*

Station with Express Bus Terminal*

* All rail stations will have local bus connections

Frequency of Service

	Peak	Off Peak
Central	5	10

Fig 2-4 automated guideway.cdr

4.6 Light Rail Plus Commuter Rail

This option (see **Figure 4-5**) was developed by combining the previously developed Light Rail and Commuter Rail option with the following changes:

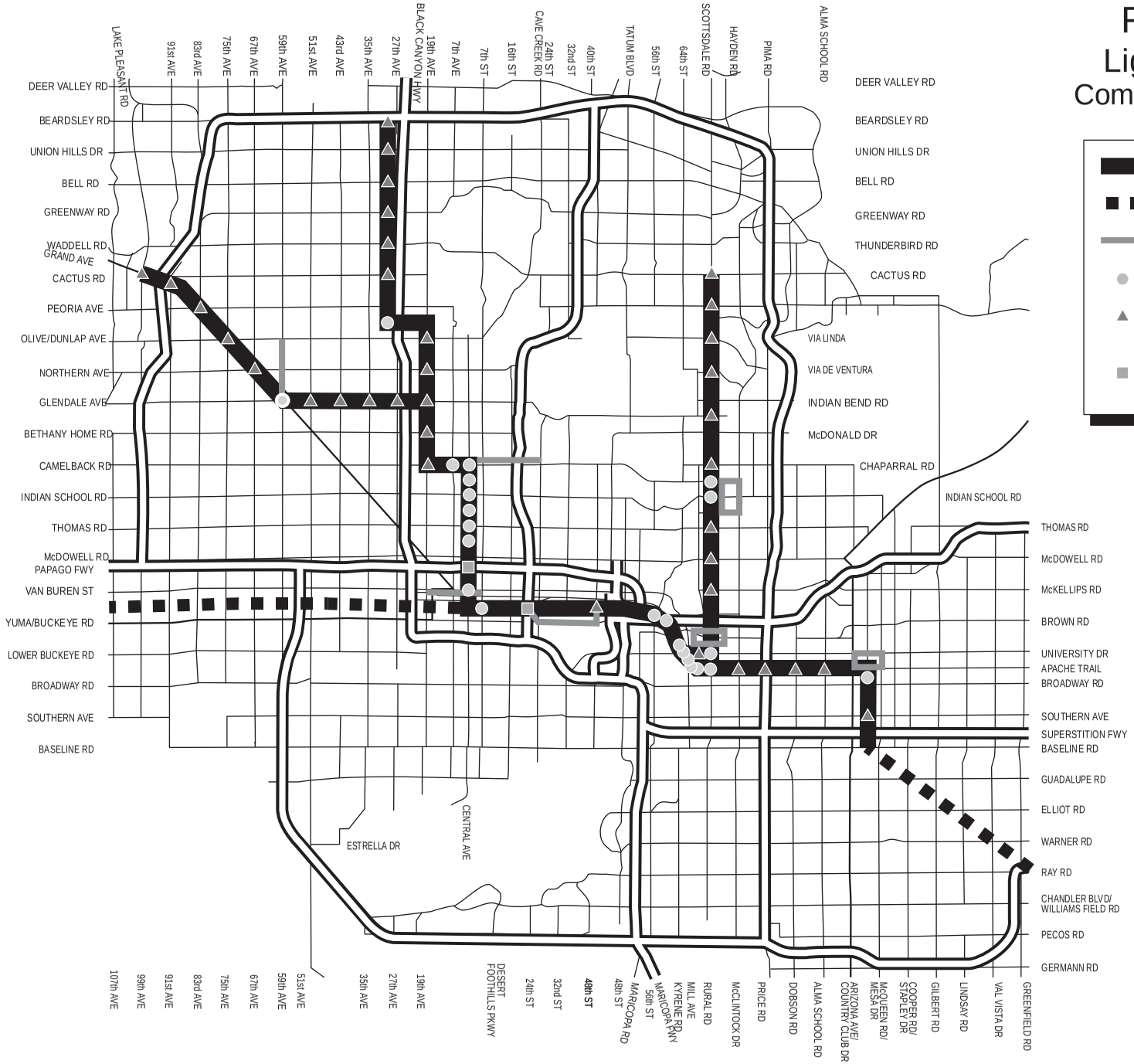
1. Eliminated Light Rail service in the East Valley, south of Southern.
2. Included commuter rail service only on the Union Pacific line from near Cotton Lane on the west through downtown Phoenix, Tempe, Mesa, and Chandler to near Riggs Road.
3. Local bus, express bus and circulator bus services were adjusted to avoid duplication. Peak period light rail service frequency is 10 minutes headways, with 20 minute headways in the off-peak period. As routes combine, service it more frequent in the core areas. Commuter rail service is provided at 30 minute headways, with service in the peak period direction of travel only, eg., inbound in the AM and outbound in the PM.

4.7 Light Rail Plus Express Bus

This option (see **Figure 4-6**) is a combination of the Light Rail option and expanded express bus service with the following adjustments:

1. Light Rail lines would be shortened as follows: (1) Northwest line terminates near 59th Avenue; and (2) North line terminates near Cactus Road, Scottsdale line terminates near Loop 202 and Southeast Valley line terminates near Broadway Road. The concept is to extend lines just beyond activity centers to a major park-and-ride lot.
2. Local bus and bus circulators were adjusted to minimize duplication.
3. Duplicative express bus service that primarily services origins also served by light rail was eliminated.

Figure 4-5
Light Rail Plus
Commuter Rail Option



Light Rail Line

Commuter Rail Line

Circulator Route

Rail Station*

Station with Park and Ride*

Station with Express Bus Terminal

* All rail stations will have local bus connections

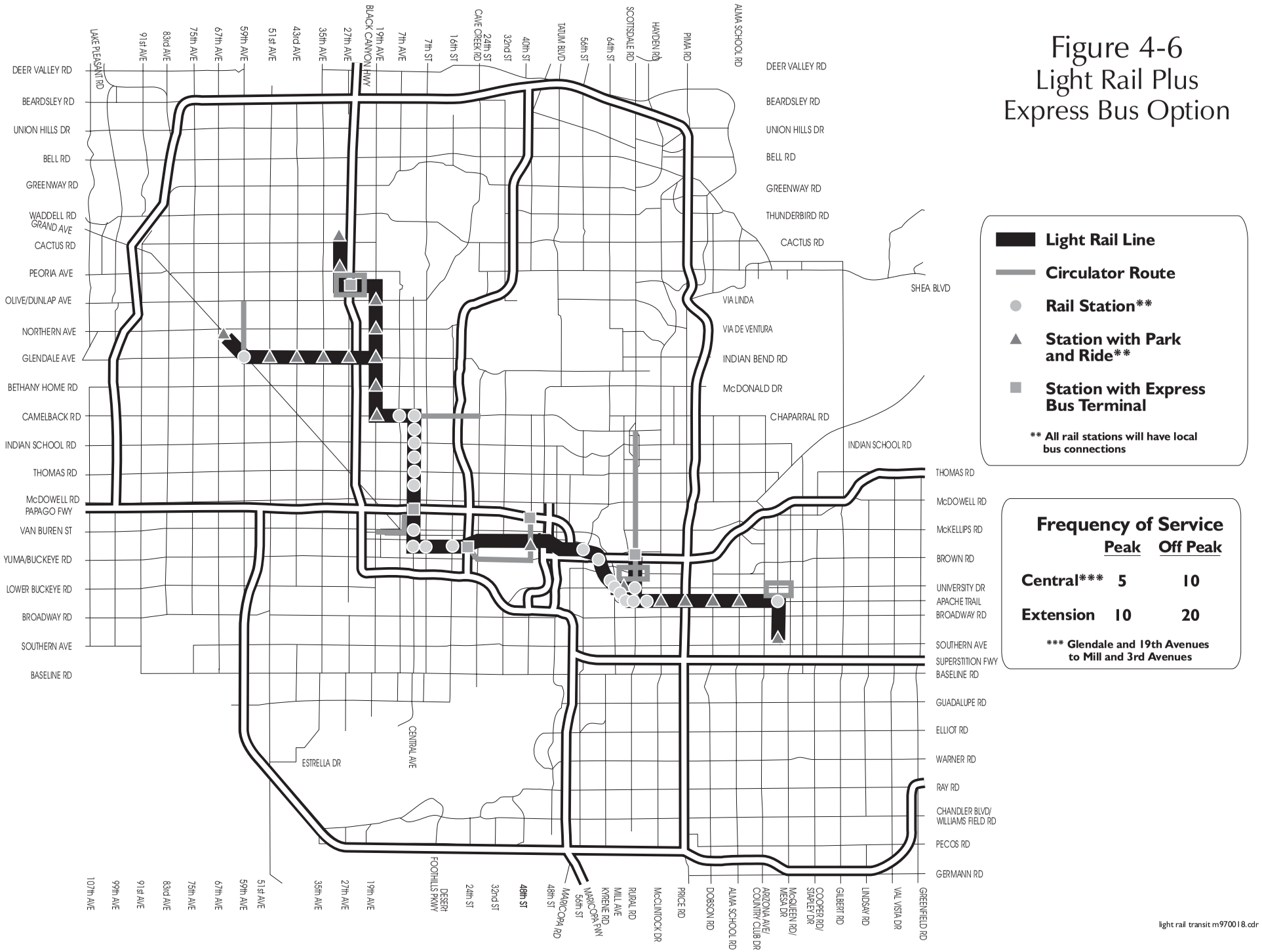
Frequency of Service

	Peak	Off Peak
Central*	5	10
Extension	10	20

* Glendale and 19th Avenues to University and S.P. Line

Fig 2-3 at grade rail.cdr

Figure 4-6
Light Rail Plus Express Bus Option



Light Rail Line

Circulator Route

Rail Station**

Station with Park and Ride**

Station with Express Bus Terminal

** All rail stations will have local bus connections

Frequency of Service

	Peak	Off Peak
Central***	5	10
Extension	10	20

*** Glendale and 19th Avenues to Mill and 3rd Avenues

light rail transit m970018.cdr

5.0 Evaluation of Fixed Guideway System Options

This chapter of the MAG Fixed Guideway System Study examines a set of fixed guideway options which incorporate previously reviewed travel corridors and transit technologies. Results of this analysis were used to develop a refined option as described in Chapter 6.

In February, 1998 the MAG Transportation Review Committee approved evaluation of the Fixed Guideway System Options based upon a set of goals and objectives addressing the following:

- Mobility
- Environment
- Social/Economic
- Financial

Within each goal area, a number of key objectives and quantitative indicators were identified for measuring the performance of the Fixed Guideway System Options. Each of the Fixed Guideway System Options was modeled using the MAG Regional Travel Demand Model to derive transit ridership and performance data for the year 2020. (Note: Due to the fact that the MAG travel demand model is currently being updated, ridership estimates should be viewed as preliminary.) Annualized estimates of both capital and operation and maintenance costs were also developed for each system option for the year 2020. The service performance and cost data provided the basis for comparison of each of the system options with the existing MAG Long Range Transit Plan (Double Bus).

5.1 Transit Service Comparisons

This section provides a comparison of daily transit revenue rail and transit service frequencies for each of the system options.

Revenue Miles of Transit Service

Daily revenue miles of transit service provides a good measure and basis for comparison of the amount of transit service provided by each of the system options. **Table 5.1** displays daily revenue miles of transit service by mode for each of the system options, including magnitude of change from the existing MAG Long Range Transit Plan.

As shown in Table 5.1, Express Bus/Busway option provides the largest amount additional revenue miles of transit service, compared to the existing Plan. The significant majority of this increase is express bus service. The remaining system options by focusing an additional rail service, provide a lesser amount of additional transit revenue miles.

Table 5.1
Daily Revenue Miles of Transit Service by Mode

Mode	Plan	Change from Plan					
		Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Local Bus	130,761	102	3,610	(284)	(1,644)	(284)	(2,174)
Express Bus	11,528	50,480	(3,480)	(6,504)	(5,232)	(6,752)	4,640
Commuter Rail	0	0	3,960	0	0	1,560	0
Light Rail	0	0	0	12,392	9,000	11,325	8,100
Shuttle	646	3,906	2,434	3,437	3,022	3,237	4,781
Total	**142,935**	**54,488**	**6,524**	**9,041**	**5,146**	**9,086**	**15,347**

Source: MAG, BRW, October 1998

Transit Service Frequency

The frequency of transit service is an important consideration in the ability of transit to attract ridership. **Table 5.2** displays average transit service frequency by mode for each of the system options.

All options concentrate service in the peak period for 8 hours of the 19 hours of service per day. The frequency of off-peak weekday service is one-half of peak period service while weekend service was assumed to be one-half the frequency of off-peak period service.

As shown in table 3.2, service frequency assumption were generally consistent by mode type across the system options. Express bus and commuter rail would be provided only in the peak period and peak direction and off-peak local bus frequencies would be relatively similar.

Table 5.2
Average Transit Service Frequency

Mode	Plan		Express Bus/Busway		Commuter Rail		Light Rail		Automated Rail		Light Rail Plus Commuter Rail		Light Rail Plus Express Bus	
	Peak	Off-peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak	Peak	Off-Peak
Local Bus	30	31	30	31	30	31	30	31	30	31	30	31	30	31
Express Bus	30	N/A	15	N/A	30	N/A	30	N/A	30	N/A	30	N/A	30	N/A
Light Rail	N/A	N/A	N/A	N/A	N/A	N/A	10	20	5	10	10	20	10	20
Commuter Rail	N/A	N/A	N/A	N/A	30	N/A	N/A	N/A	N/A	N/A	30	N/A	N/A	N/A
Shuttle	8	11	8	N/A	8	N/A	8	15	8	15	8	15	8	16
Average	30	30	29	31	29	31	28	29	29	29	28	29	28	29

Source: MAG, BRW, October 1998

5.2 Transit Performance Comparisons

This section provides a comparisons of transit ridership, passenger miles, travel times and highway impacts for each of the system options.

Mode Share Impacts

Table 5.3 displays 2020 person trips by mode for the Plan, and the change from Plan associated with each of the system options. The resulting 2020 transit mode share is also displayed.

Table 5.3
2020 Mode Share Comparisons
Daily Person Trips By Mode

Mode	Plan	Change from Plan					
		Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Total Auto	14,729,650	(16,390)	(2,030)	(11,240)	(5,650)	(9,330)	(8,110)
Drive Alone	8,479,320	(12,250)	10,010	(4,270)	17,000	5,040	5,880
Shared Ride	6,250,330	(4,140)	(12,040)	(15,510)	(15,150)	(14,370)	(13,990)
Total Transit	180,230	16,410	2,040	11,230	5,660	9,350	8,120
Walk Access	171,440	7,710	(1,110)	4,960	3,410	3,830	3,130
Drive Access	8,790	8,700	3,150	6,180	2,160	5,430	4,900
Transit Mode Share	1.21%	0.11%	0.01%	0.07%	0.04%	0.06%	0.05%

Source: MAG, BRW, October 1998

As shown in Table 5.3 the Express Bus/Busway option results in the largest decrease in auto trips and the largest increase in transit trips. The increased coverage and frequency of bus service also results in substantial increase in transit trips via walk access. Of the remaining options, the Light Rail option provides the next largest increase in transit trips, with a comparable decrease in daily auto trips. The Commuter Rail option results in the smallest increase in transit trips.

Transit Trips By Purpose

Table 5.4 provides a breakdown of transit trip purposes for the Plan and change from Plan for the system options, including Home Based Work, Home Based Other, and Non-Home Based purposes. Both walk access and drive access trips are included. Table 5.4 also displays the number of daily Central Business Trip (CBD) transit trips.

As shown in Table 5.4, the majority of additional transit trips under each of the system options would be work related. While the majority of transit trips tend to be for Home Based Other purposes, the work trip became the primary candidate for additional transit service. As shown, the Express Bus/Busway option would attract the largest number of additional work trips, followed by the Light Rail option.

The Light Rail option would result in the highest number of additional CBD transit trips. The Commuter Rail option would result in the lowest number of CBD transit trips.

Table 5.4
2020 Daily Transit Trips by Purpose

Mode	Plan	Change from Plan					
		Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Home Based Work							
Walk Access	66,200	8,950	1,110	5,580	3,590	4,850	4,390
Drive Access	5,720	6,670	1,480	4,400	1,570	4,110	3,680
Total	71,920	15,620	2,590	9,980	5,160	8,930	8,070
Home Based Other							
Walk Access	87,700	(920)	(2,030)	(950)	(920)	(1,240)	(1,470)
Drive Access	2,540	1,660	560	1,540	490	1,110	1,040
Total	90,240	740	(1,470)	590	(430)	(130)	(430)
Non-Home Based							
Walk Access	17,550	(330)	(200)	340	740	210	190
Drive Access	530	360	110	340	190	290	280
Total	18,080	30	(90)	680	930	500	470
Grand Total	180,240	16,390	1,030	11,250	5,660	9,300	8,110
CBD Transit Trips	17,230	1,860	80	2,570	1,530	2,190	2,170

Source: MAG, BRW, October 1998

Transit Boardings

Table 5.5 displays 2020 daily transit boardings by mode for the Plan and the change from Plan for each of the system options.

Table 5.5
2020 Daily Transit Boardings by Mode

Mode	Plan	Change from Plan					
		Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Local Bus	290,970	(5,330)	(6,830)	(35,020)	(29,830)	(33,620)	(29,020)
Express Bus	13,450	43,190	(2,690)	(7,050)	(4,110)	(8,720)	3,210
Commuter Rail	0	0	10,340	0	0	2,920	0
Light Rail	0	0	0	50,650	43,300	44,390	34,260
Shuttle	310	14,290	2,280	3,940	3,530	3,130	7,560
Total	**304,730**	**52,150**	**3,100**	**12,520**	**12,890**	**8,100**	**16,010**

Source: MAG, BRW, October 1998

As shown in Table 5.5, the Express Bus/Busway option, followed by the Light Rail Plus Express Bus option, would result in the highest number of additional daily transit boardings. The Light

Rail option results in the highest number of rail boardings but also results in fewer local and express bus boardings, when compared with the Plan and the other system options.

Figures 5-1 through **5-6** graphically display projected year 2020 ridership for the Express Bus/Busway, Commuter Rail, Light Rail, Automated Guideway, Light Rail Plus Commuter Rail, and Light Rail Plus Express Bus options.

Transit Passenger Miles

Table 5.6 displays 2020 daily transit passenger miles by mode for the Plan and the change from Plan for each of the system options.

Table 5.6
2020 Daily Transit Passenger Miles by Mode

Mode	Plan	Change from Plan					
		Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Local Bus	1,453,770	(185,820)	(51,900)	(271,280)	(247,440)	(238,920)	(256,920)
Express Bus	145,610	606,480	(56,340)	(97,440)	(68,050)	(117,090)	77,650
Commuter Rail	0	0	172,590	0	0	38,450	0
Light Rail	0	0	0	550,180	416,140	466,210	321,850
Shuttle	250	15,210	3,380	4,620	4,530	3,980	10,450
Total	**1,599,630**	**435,870**	**67,730**	**186,080**	**105,180**	**152,630**	**153,030**

Source: MAG, BRW, October 1998

As shown in Table 5.6, the Express Bus/Busway option provides the highest number of transit passenger miles, followed by the Light Rail option. The Commuter Rail option results in the lowest daily transit passenger miles.

Generally, local bus passenger miles decrease for each of the system options, as passengers utilize express modes for longer rail trips. The Light Rail option results in the highest number of rail transit passenger miles, while also exhibiting the largest decrease in local and express bus passenger miles, compared to the Plan.

Highway Impacts

Table 5.7 displays a number of parameters related to highway and congestion related impacts, including peak hour and daily vehicle miles of travel (VMT) and congested lane miles as indicated by volume-to-capacity ratio greater than 0.9 in the peak hour.

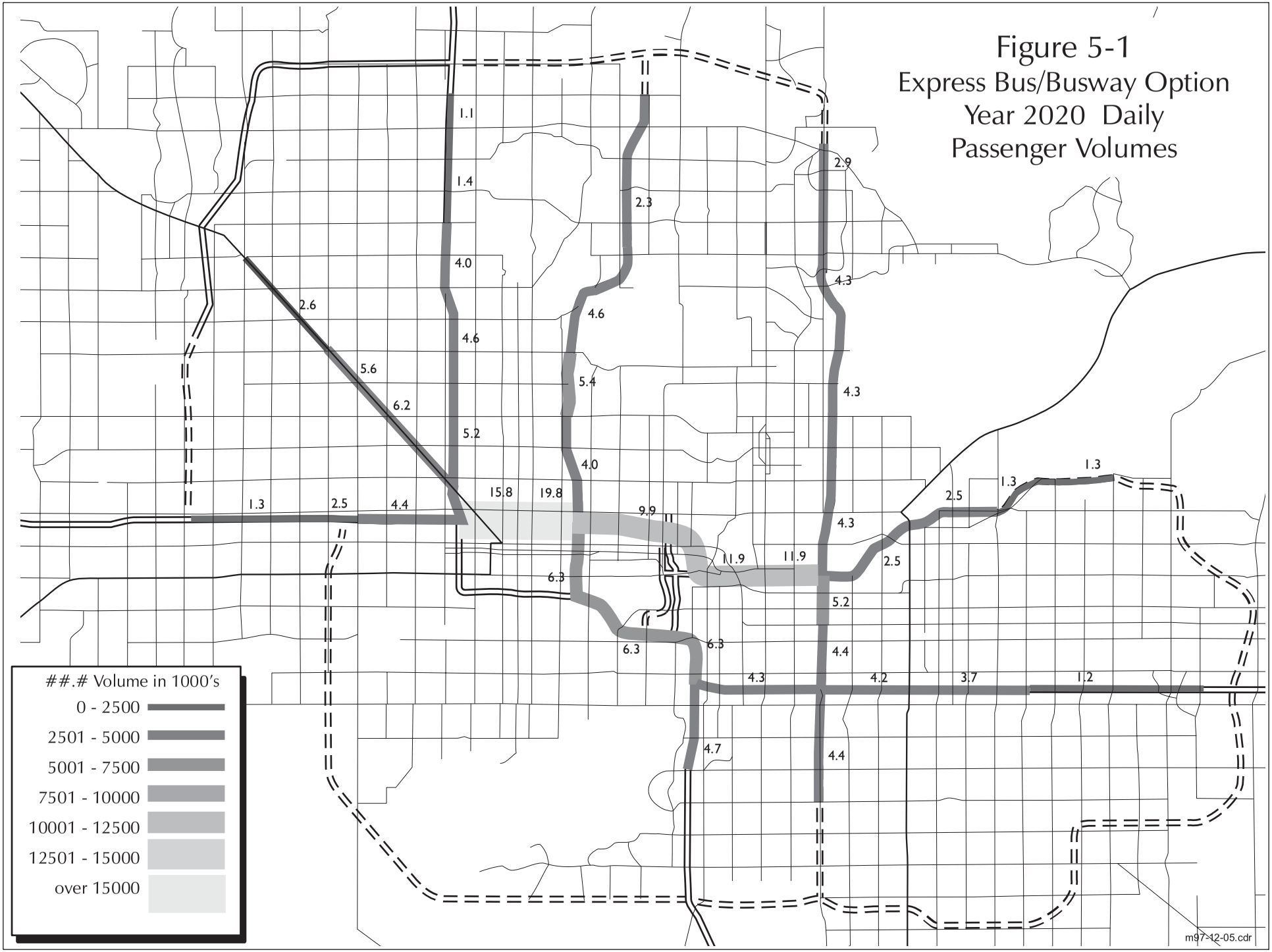


Figure 5-1
Express Bus/Busway Option
Year 2020 Daily
Passenger Volumes
##.# Volume in 1000's
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 12500
12501 - 15000
over 15000
1.1
1.4
4.0
2.6
4.6
5.6
6.2
5.2
1.3
2.5
4.4
15.8
19.8
4.0
2.3
2.9
4.3
4.6
5.4
4.3
9.9
4.3
11.9
11.9
2.5
6.3
5.2
6.3
6.3
4.4
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4.4
1.3
1.3
2.5
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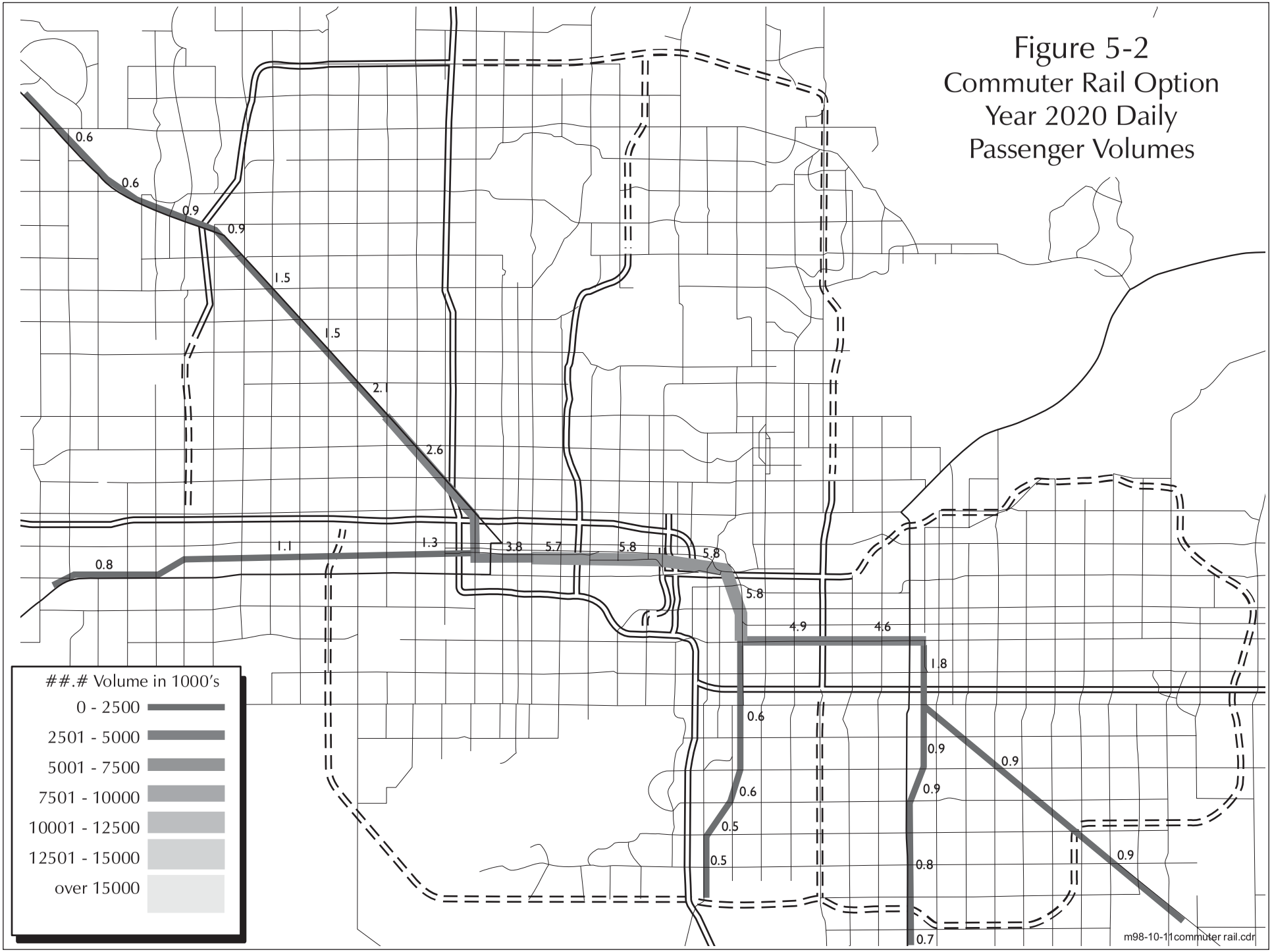


Figure 5-2
Commuter Rail Option
Year 2020 Daily
Passenger Volumes
0.6
0.6
0.9
0.9
1.5
1.5
2.1
2.6
0.8
1.1
1.3
3.8
5.7
5.8
5.8
5.8
4.9
4.6
1.8
0.6
0.9
0.9
0.6
0.9
0.5
0.5
0.8
0.9
0.7
##.# Volume in 1000's
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 12500
12501 - 15000
over 15000
m98-10-11commuter rail.cdr

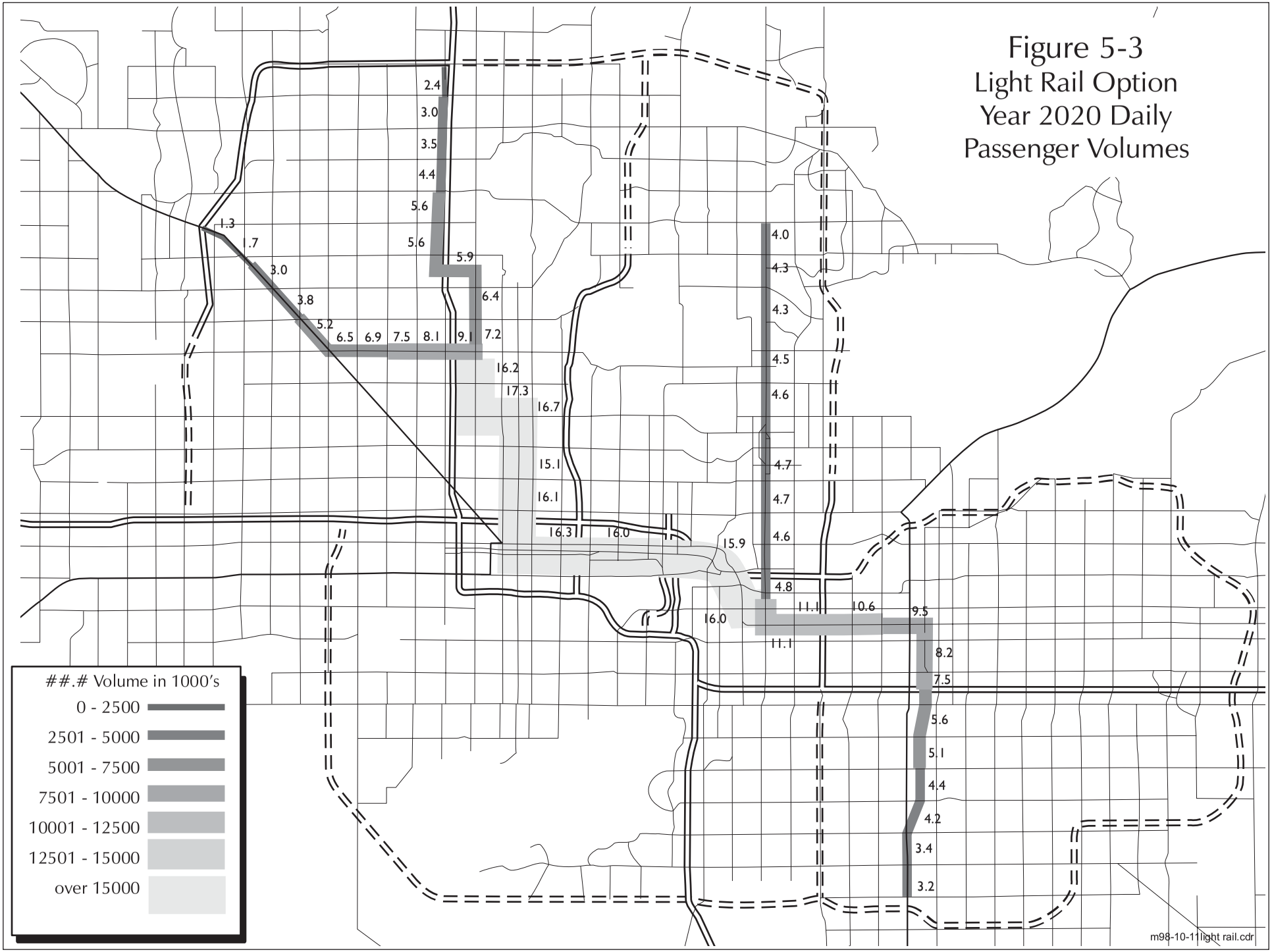


Figure 5-3
Light Rail Option
Year 2020 Daily
Passenger Volumes
##.# Volume in 1000's
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 12500
12501 - 15000
over 15000
m98-10-11light rail.cdr

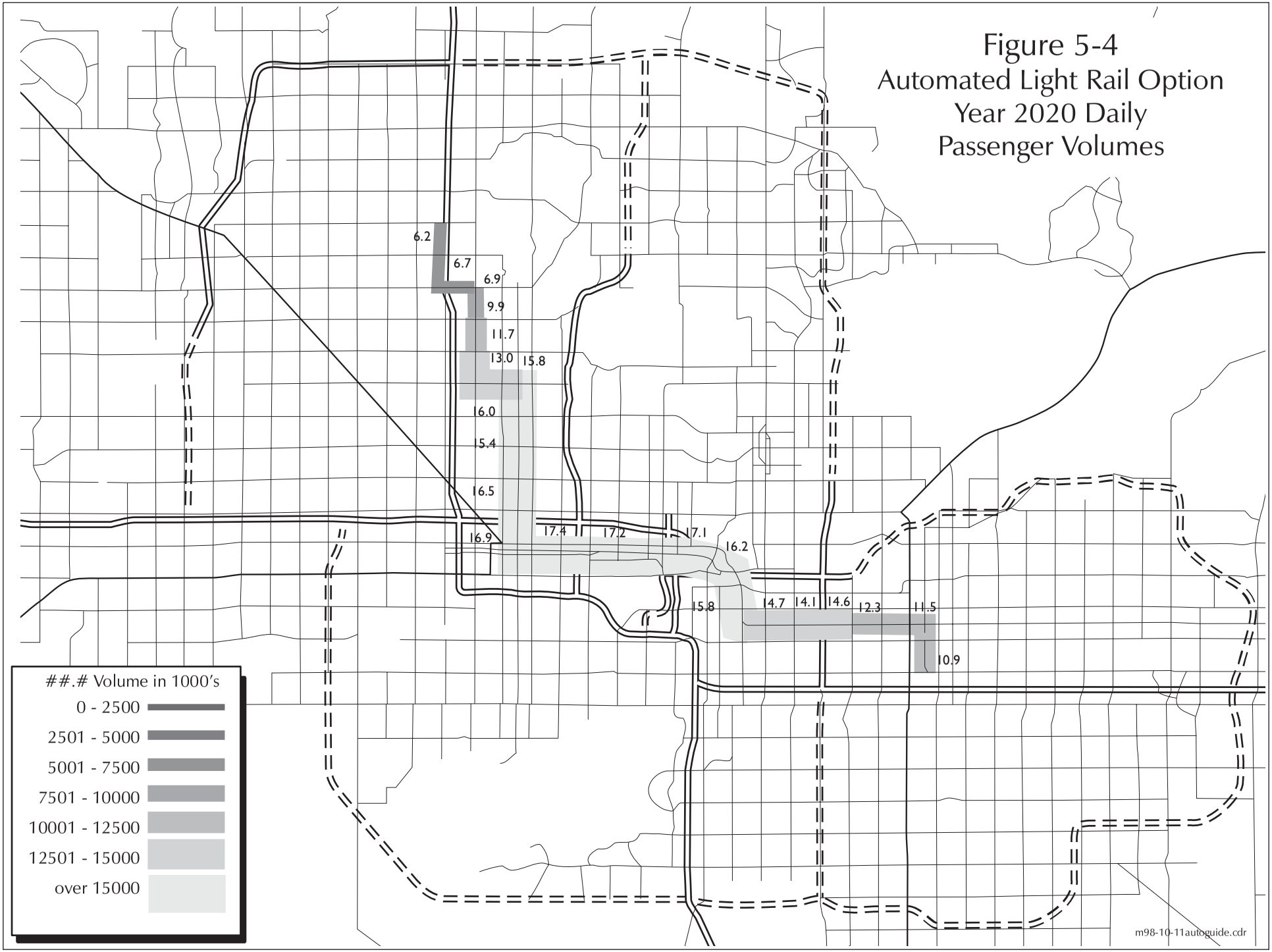


Figure 5-4
Automated Light Rail Option
Year 2020 Daily
Passenger Volumes
6.2
6.7
6.9
9.9
11.7
13.0
15.8
16.0
5.4
16.5
16.9
17.4
17.2
17.1
16.2
15.8
14.7
14.1
14.6
12.3
11.5
10.9
##.# Volume in 1000's
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 12500
12501 - 15000
over 15000
m98-10-11autoguide.cdr

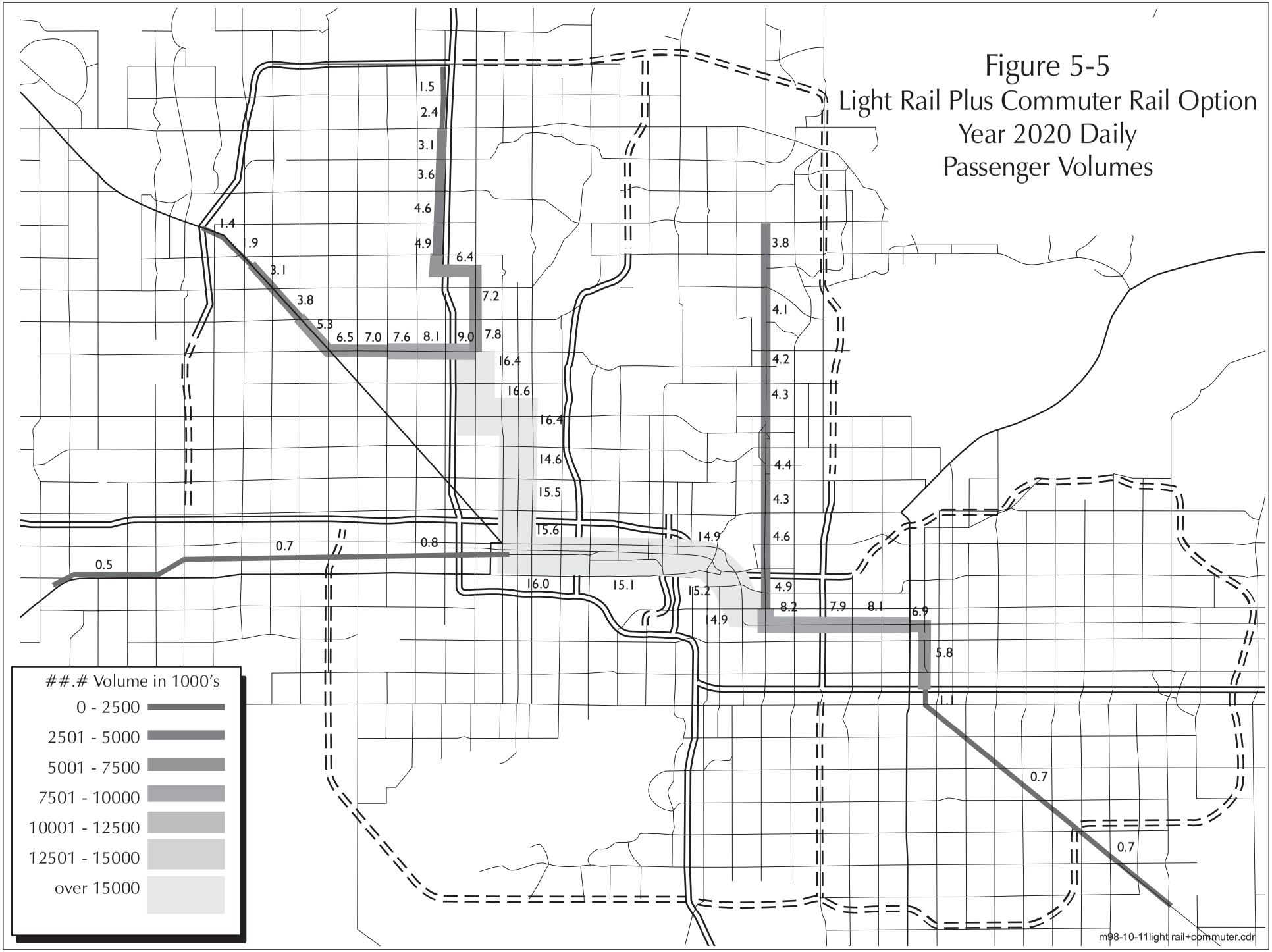


Figure 5-5
Light Rail Plus Commuter Rail Option
Year 2020 Daily
Passenger Volumes
##.# Volume in 1000's
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 12500
12501 - 15000
over 15000
1.5
2.4
3.1
3.6
4.6
4.9
1.4
1.9
3.1
3.8
5.3
6.5
7.0
7.6
8.1
9.0
6.4
7.2
7.8
16.4
16.6
16.4
14.6
15.5
15.6
16.0
15.1
15.2
14.9
14.9
0.5
0.7
0.8
3.8
4.1
4.2
4.3
4.4
4.3
4.6
4.9
8.2
7.9
8.1
6.9
5.8
1.1
0.7
0.7
m98-10-11light rail+commuter.cdr

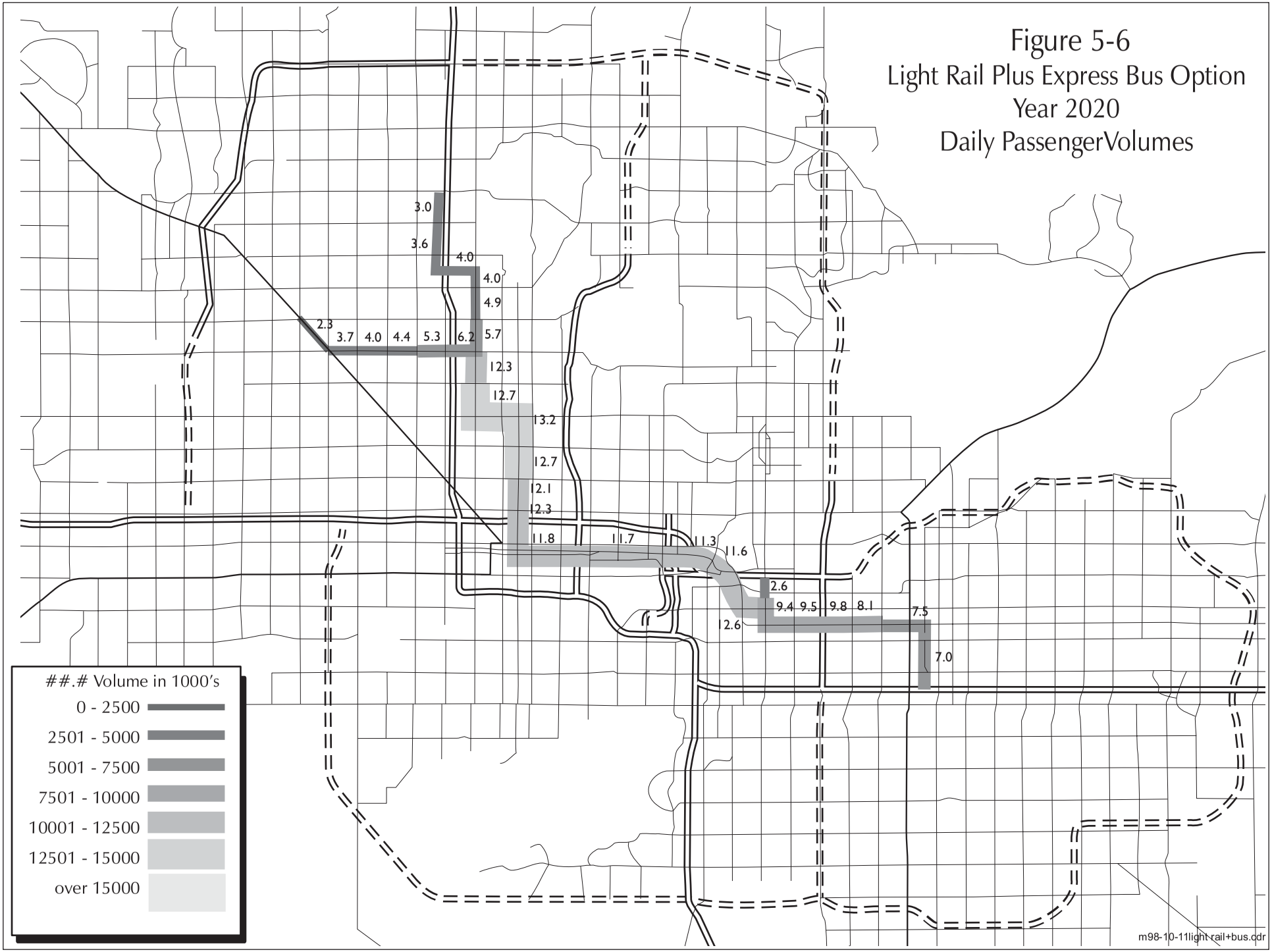


Figure 5-6
Light Rail Plus Express Bus Option
Year 2020
Daily PassengerVolumes
3.0
3.6
4.0
4.0
4.9
2.3
3.7
4.0
4.4
5.3
6.2
5.7
12.3
12.7
13.2
12.7
12.1
12.3
11.8
11.7
11.3
11.6
2.6
9.4
9.5
9.8
8.1
7.5
12.6
7.0
##.# Volume in 1000's
0 - 2500
2501 - 5000
5001 - 7500
7501 - 10000
10001 - 12500
12501 - 15000
over 15000
m98-10-11light rail+bus.cdr

Table 5.7
2020 Highway Impacts

		Change from Plan					
	Plan	Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Peak Hour VMT	9,000,480	(17,860)	(73,650)	(79,960)	(60,850)	(76,210)	(83,430)
Daily VMT	109,534,660	(368,390)	(852,820)	(1,020,260)	(831,180)	(990,220)	(1,056,750)
Lane Miles with V/C>0.9 in Peak Hour	1,900	(330)	(80)	(100)	(120)	(100)	(110)

As shown in Table 5.7, each of the system options, when composed with the Plan, result in decreased daily and peak hour VMT. The Light Rail Plus Express Bus option shows the largest decrease in peak hour and daily VMT. The Express Bus/Busway option results in the largest decrease in congested lane miles. It is important to note that this option includes additional roadway and HOV improvements which benefit reduced congested.

5.3 Cost Comparisons

The costs for each of the system options were annualized to provide total costs including both annual operation and maintenance, (O&M) as well as capital and construction related items as shown in **Table 5.8**.

Capital costs were annualized using a 7% discount rate with the following lifespan assumptions:

Vehicles –	12 year for local/express buses/rail vehicles 10 years for shuttles
Trackwork -	25 years
Passenger facilities -	11 years for major 8 years for minor
Maintenance facilities -	10 years
Roadways -	30 years
Other related capital -	5 years

TDM/special needs and Dial-a-Ride costs were not included in this analysis. **Appendix B** provides detailed breakdown of the annualized O&M and capital costs for each of the options.

Table 5.8
2020 Annualized Costs
(Millions of 1998 $s)

	Plan	Change from Plan					
		Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Operation/ Maintenance (O&M)	146.663	57.960	7.873	19.839	13.189	19.703	23.116
Capital	118.805	125.061[1]	156.136	173.272	184.165	200.472	119.553
Total	**$265.465**	**$183.021**	**$164.009**	**$193.111**	**$197.354**	**$220.175**	**$142.669**

Source: MAG, BRW, October 1998

[1] Does not include roadway improvements estimated at $74.14 Million (2020 Annualized) for Grand Ave. and Freeway HOV lane additions.

As shown in Table 5.8, the Express Bus/Busway option includes the highest operation and maintenance cost requirements. The Light Rail Plus Express Bus option results in the lowest overall additional costs, relative to the Plan. The Light Rail Plus Commuter Rail would be the most expensive option to construct, operate and maintain.

5.4 Socioeconomic Impacts

This section address potential socioeconomic impacts of the fixed guideway system options, including impacts on Title VI Factors, such as low income households, minorities, age and gender.

Title VI Factors

Title VI of the 1964 Civil Rights Act prohibits discrimination on the basis of race, color, and/or national origin. In addition, other federal laws prohibit discrimination based on age, gender, and/or disability. **Table 5.9** displays the authority and area of discrimination covered under Title VI federal laws and directives.

Table 5.9
Title-Vi-Federal and Directives

Federal Authority	Areas of Discrimination
Title VI of the Civil Rights Act of 1964	Race, color, national origin
Age Discrimination Acts of 1967 and 1975	Age
Section 504 of the Rehabilitation Act of 1973	Disability
Civil Rights Restoration Act of 1973	Race, color, national origin, age, gender, handicapped/disability
Americans with Disabilities Act of 1990	Disability
Title IX of the Education Amendments of 1972	Discrimination in employment
Title 23, U.S. Code, Section 324 (Federal Highway Act of 1973)	Gender
Executive Order 12898 (1994)	Environmental justice in minority and low income populations

Source: MAG Systems Management Report; 1997

Low-Income Households

In 1995 the low-income threshold for a family unit of four people was defined as an annual income of $15,150 or less. In 1989 the average poverty rate for Pima and Maricopa Counties was 13.5 percent. Table 4.2 displays the number of 2020 transit trips from low-income household for each of fixed guideway system options. **Figure 5-7** displays the regional distribution of low-income households.

Table 5.10
2020 Daily Transit Trips From
Low Income Households

		Change of Plan					
	Plan	Express Bus/Busway	Commuter Rail	Light Rail	Automated Rail	Light Rail Plus Commuter Rail	Light Rail Plus Express Bus
Low Income Transit Trips	73,850	3,360	(100)	1,880	970	1,430	1,460

Source: MAG, BRW, October 1998

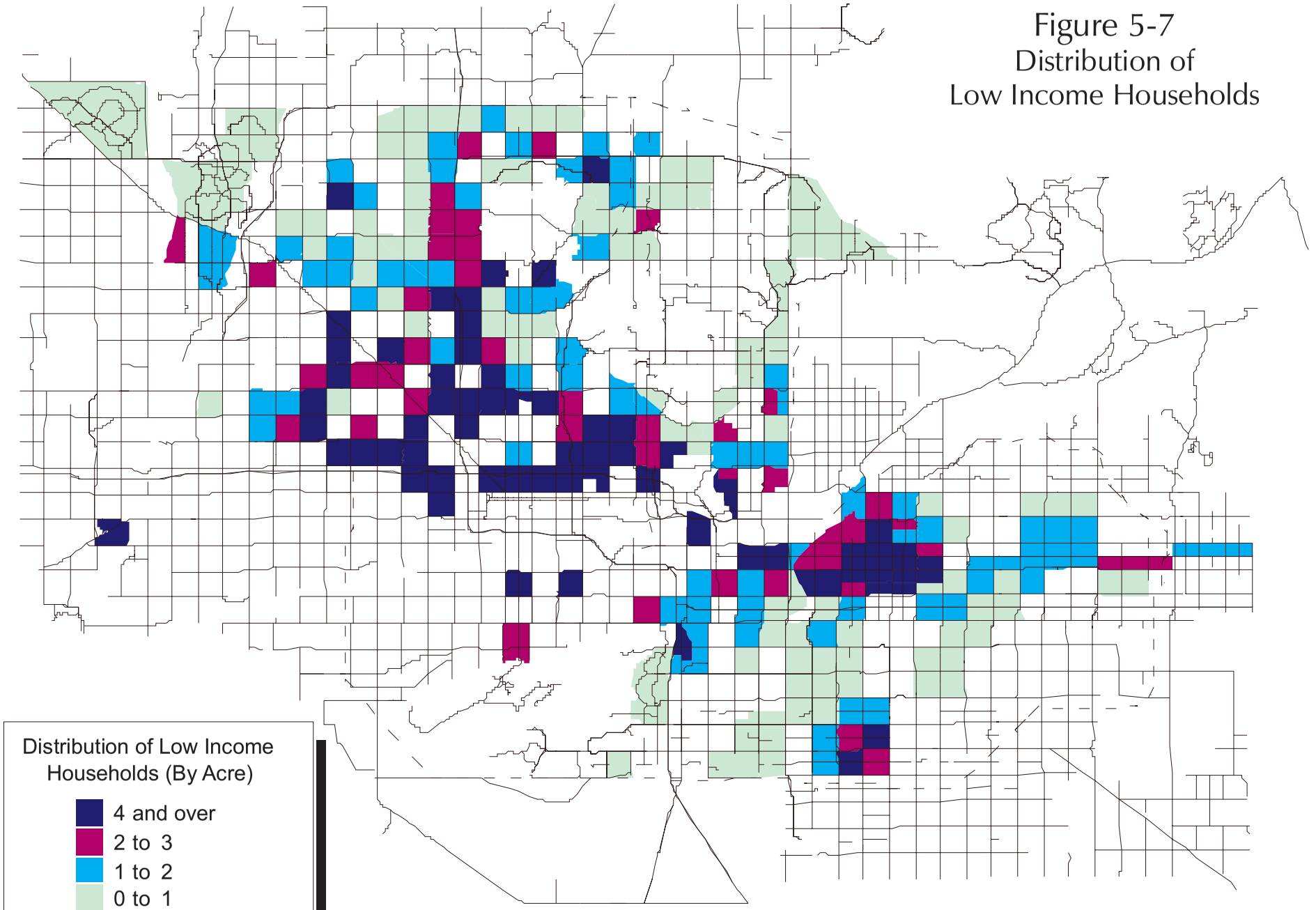
As shown in **Table 5.10**, due to expanded regional coverage and frequent service the Express Bus/Busway option would result in the highest number of low-income transit trips. The Commuter Rail option would result in the lowest number of low income transit trips, primarily due to its focus on peak-period commuter-related service. The suburban to central areas focus of commuter rail is generally not supportive of low income travel needs. Low income households are more likely to be dependent on walk and/or bus access to station locations, as opposed to higher income households which may have a higher percentage of park-and-ride/kiss-and-ride station access trips. Good walk access is important for low-income households.

Ethnic Minorities

Caucasians comprised 85 percent of the Maricopa County population in 1990. Hispanics comprised 16 percent, Blacks 3.5 percent, Native American, American Indian, Eskimo, Aleut 2 percent, and Asian/Pacific Islanders 2 percent. Hispanic populations may represent a somewhat larger percentage of the population ethnic makeup as Hispanic persons can be considered a member of any racial category. **Figure 5-8** displays the regional distribution of minority populations, while **Figure 5-9** displays the distribution of Hispanic population.

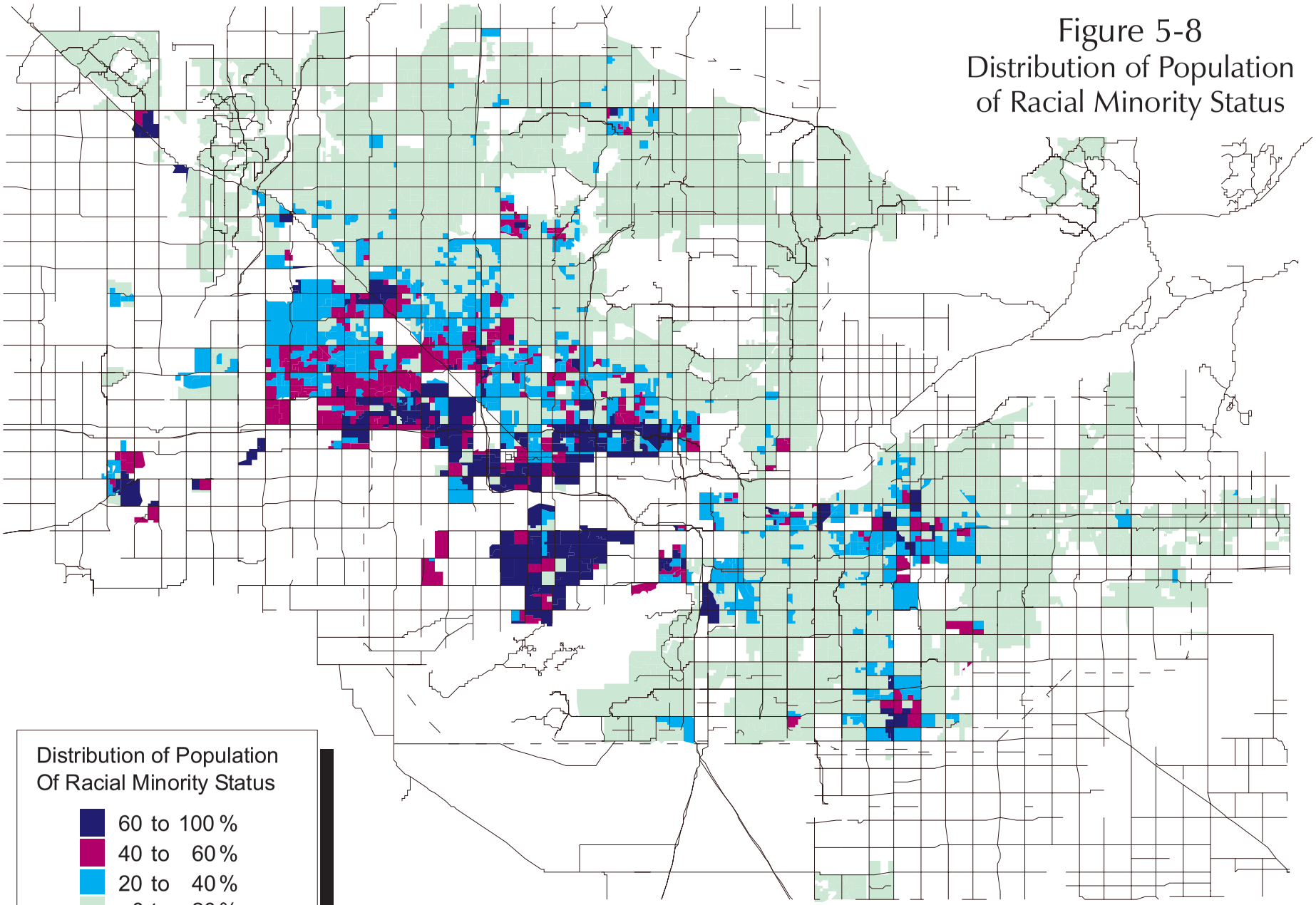
Of the modal options considered, each has a viable opportunity to provide effective service to ethnic communities. However, the Light Rail and Light Rail Plus Express Bus options may provide for a greater number of stops and more expansive service allowing for a better regional distribution of service among various communities. The Commuter Rail option may prove the least effective in servicing ethnic communities as the limited number of stops may not be as easily distributed across the region.

Figure 5-7
Distribution of Low Income Households



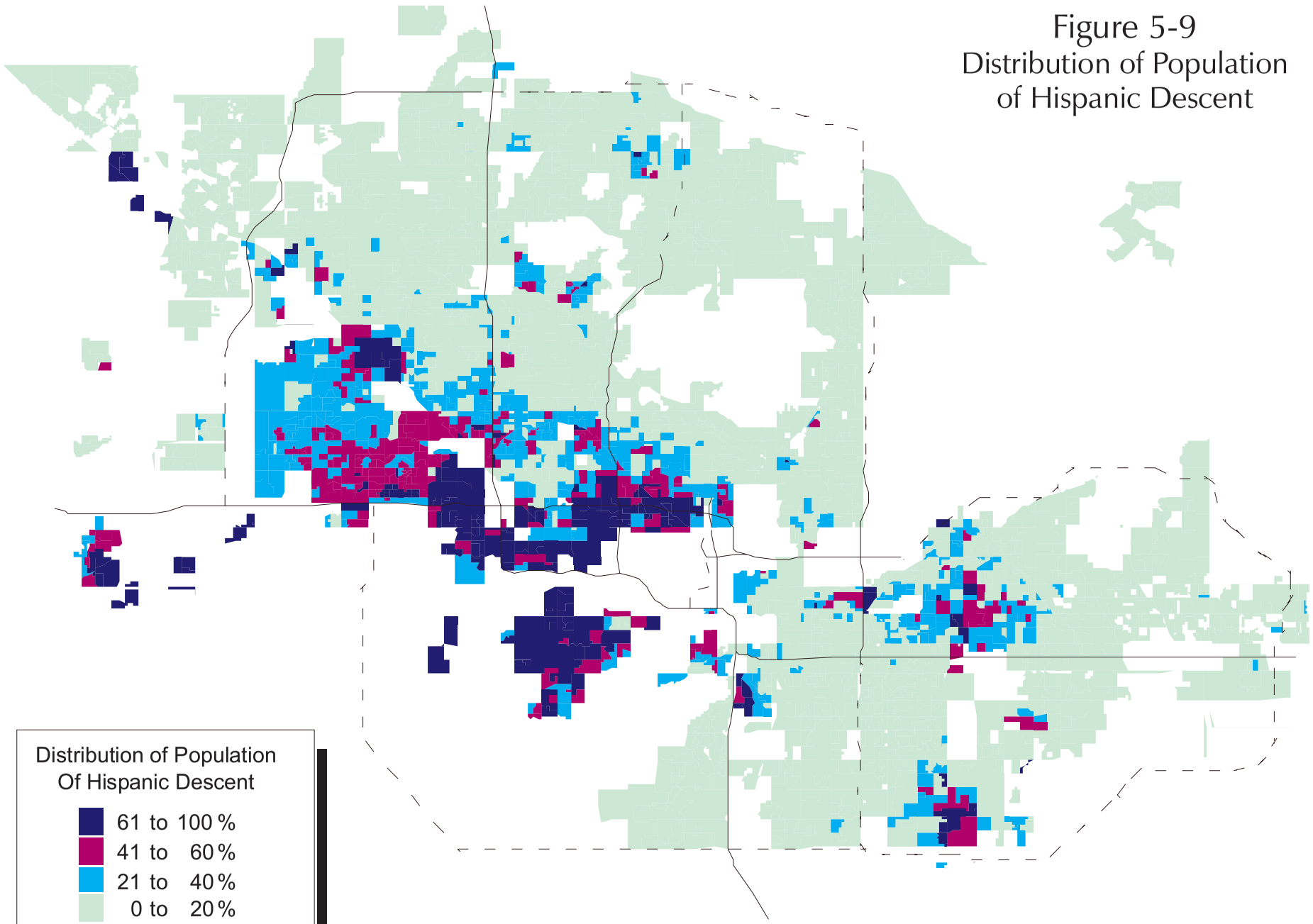
1995 Special Census Data shown by Census Tract.
Tracts with 20 persons or less, or 20 persons per square mile or less, have been excluded.

Figure 5-8
Distribution of Population of Racial Minority Status



1995 Special Census data shown by Enumeration District. Districts with 20 persons or less, or 20 persons per square mile or less, have been excluded. Minority Status does not include persons of Hispanic Descent. Please see Figure XI-2.

Figure 5-9
Distribution of Population of Hispanic Descent



1995 Special Census data shown by Enumeration District.
Districts with 20 persons or less, or 20 persons
per square mile or less, have been excluded

Gender

There is no reason to believe that any one of the modal options would benefit one gender over another given equivalent levels of income. However, female-headed households represent 13 percent of Maricopa County households, and these households are more likely to have an overall lower annual income than a two-member headed household. In addition, these households are widely distributed across the region. In the case of single-headed households, the same perspective as applied to low income households may be applied. Overall, the Light Rail and Light Rail Plus Express Bus options may provide the most effective service to a broader range of female headed households.

Age

Figure 5-10 displays the population distribution for persons age 60 and over. As shown in the figure, age data on Maricopa County populations indicates that elderly populations are relatively well distributed throughout the region with clusters of elderly persons occurring in retirement communities such as Sun City and Sun City West which were developed specifically to service elderly/retired populations. Many elderly persons may not have access to an automobile, and travel time is likely to be less critical than accessibility. For these reasons, the Light Rail and Light Rail Plus Express Bus options are most likely to provide better access and service to a broader range of elderly populations.

Functionally Limited

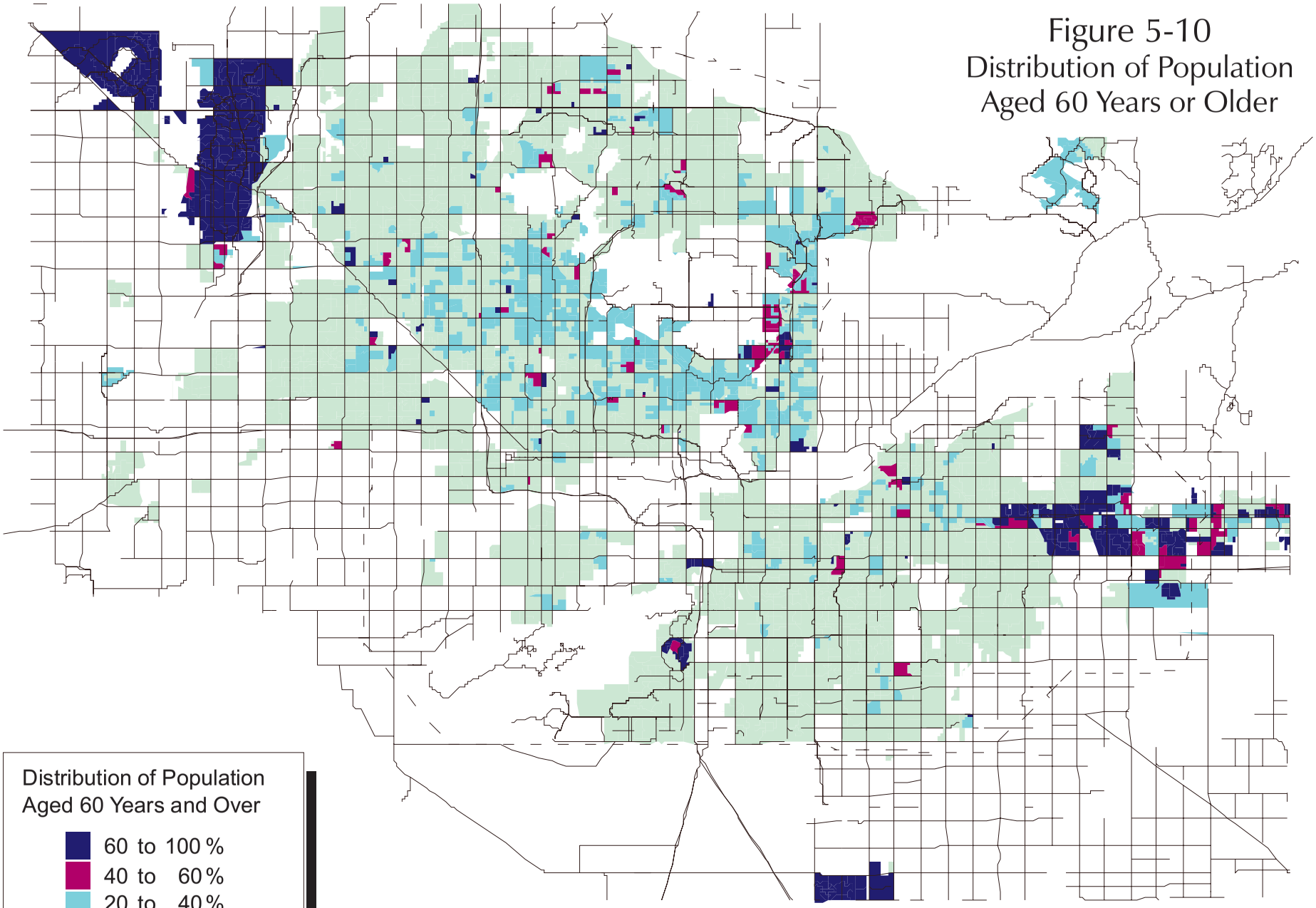
According to 1990 Census data, approximately 1.5 percent of Maricopa County's population is functionally limited in terms of mobility. Consistent with the Americans with Disabilities Act (ADA) requirements, every publicly offered modal option must make provisions for mobility-limited individuals. **Figure 5-11** displays the regional population distribution of mobility-limited individuals.

Mobility limited individuals are less likely to have the auto mode as an option and, therefore, are likely to prefer service which provides more frequent stops rather than enhanced travel time. This means that the Light Rail and Light Rail Plus Express Bus options may provide the most effective service for mobility-limited individuals. Of these two options, the Light Rail Plus Express Bus option is likely to provide the best service as demographics data for Maricopa County indicates that the mobility-limited population is widely distributed across the region, and this option is likely to reach a wider percentage of these individuals with some level of improved transit service.

5.5 Performance and Cost Effectiveness Criteria

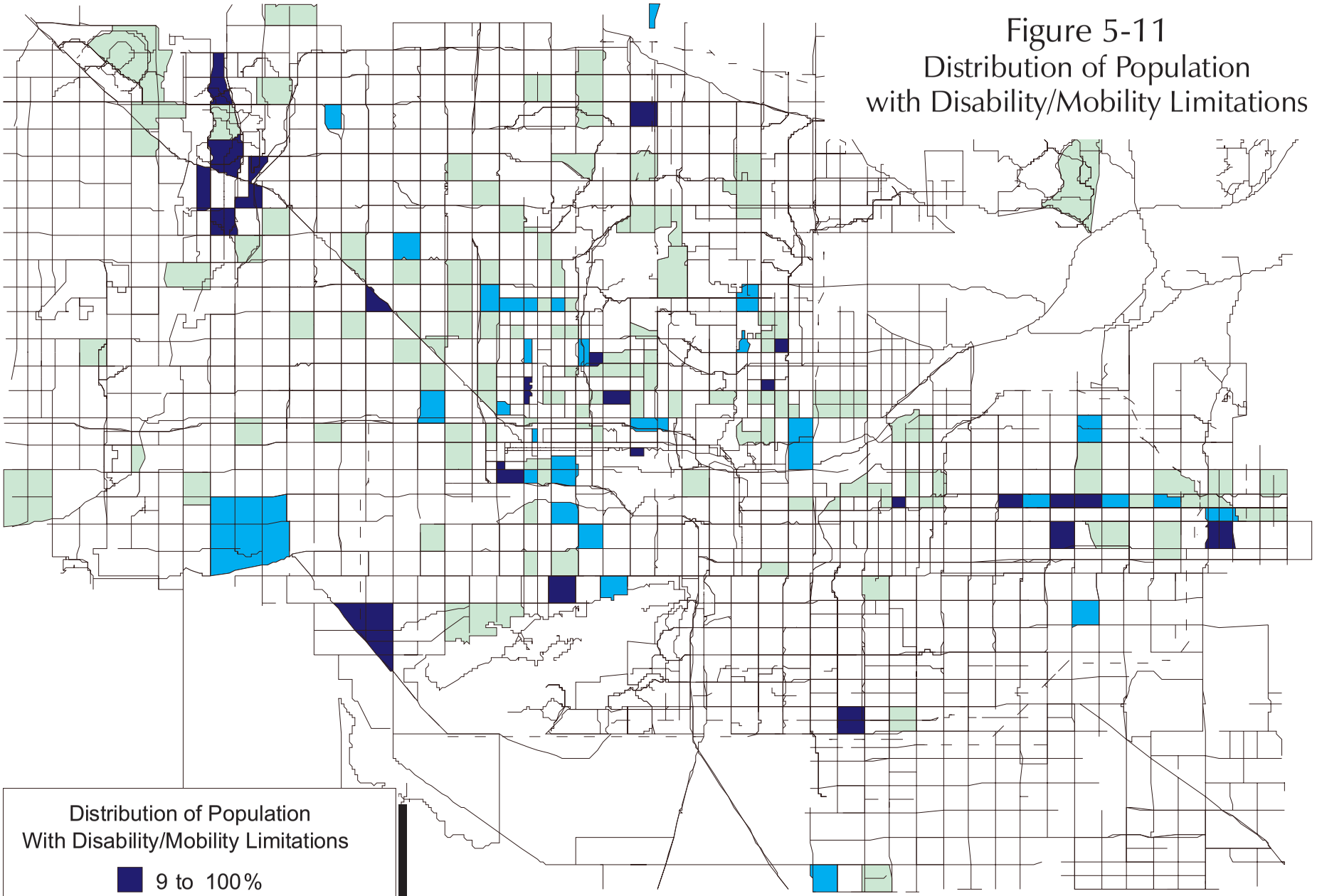
Specific evaluation criteria were developed and applied as performance indicators of how well a particular system option would achieve specific regional mobility, environmental, social/economic and financial goals and objectives with the primary focus on the cost-effectiveness of the alternatives. Each evaluation criteria was applied via the cost of the alternative (annualized capital, operation and maintenance) per unit of performance, such as transit boardings or reduction in highway congestion. The following evaluation criteria were utilized:

Figure 5-10
Distribution of Population Aged 60 Years or Older



1995 Special Census data shown by Enumeration District.
Districts with 20 persons or less, or 20 persons
per square mile or less, have been excluded

Figure 5-11
Distribution of Population with Disability/Mobility Limitations



The population with Disability/Mobility Limitations used in this map includes persons of 15 years of age and older

Goal 1: Improve Regional Mobility

Objective 1.1– Increase Transit Usage

Evaluation Criteria:

- Annual Transit Trips
- Annual Transit Passenger miles
- Cost per transit trip
- Cost per transit passenger mile

Objective 1.2 – Increase Transit Availability

Evaluation Criteria:

- Annual transit revenue miles
- Cost per transit revenue mile

Objective 1.3 – Improve traffic flow

Evaluation Criteria:

- Lane miles experiencing p.m.- peak hour congestion
- Cost per decrease in lane miles experiencing P.M. peak hour congestion.

Objective 1.4 – Reduce auto dependence

Evaluation Criteria:

- Transit mode share
- Annual vehicle miles of travel (VMT)
- Cost per change in transit mode share
- Cost per decrease in annual vehicle miles of travel (VMT)

Goal 2: Minimize Impacts On the Environment

Objective 2.1 – Improve air quality

Evaluation Criteria:

- Decrease in lane miles experiencing p.m. peak hour congestion
- Decrease in annual vehicle miles of travel (VMT)
- Cost per decrease in lane miles experiencing p.m. peak hour congestion
- Cost per decrease in annual vehicle miles of travel (VMT)

Objective 2.2 – Reduce energy dependence

Evaluation Criteria:

- Decrease in annual vehicle miles of travel (VMT)
- Cost per decrease in annual vehicle miles of travel (VMT)

Goal 3: Support Community Social and Economic Goals

Objective 3.1 – Support Development in Core Areas

Evaluation Criteria:

- Annual Transit trip ends in central CBD areas
- Cost per transit trip in central CBD area

Objective 3.2 – Provide access to jobs

Evaluation Criteria:

- Annual Transit work trips
- Cost per transit work trip

Objective 3.3 – Enhance Service to Low Income Households

Evaluation Criteria:

- Annual transit trips from low income households
- Cost per transit trip from lower income households

Goal 4: Maximize Financial Viability

Objective 4.1 – Enhance local funding feasibility

Evaluation Criteria:

- Total 2020 annualized operating costs
- Percent of total 2020 costs which are operations related

Objective 4.2 – Enhance federal funding feasibility

Evaluation Criteria:

- Total 2020 annualized capital costs
- Percent of total 2020 costs which are capital related

Objective 4.3 – Ensure long term capital value

Evaluation Criteria:

- Annual 2020 annualized capital costs
- Percent of total 2020 costs which are capital related

Objective 4.4 – Maximize flexibility to adjust to change

Evaluation Criteria:

- Total 2020 annualized operating costs
- Percent of total 2020 costs which are operations related

Objective 4.5 – Maximize transit farebox recovery

Evaluation Criteria:

- Total annual transit boardings per transit revenue mile.

5.6 Performance and Cost - Effectiveness Evaluation Results

This section presents the results of the performance and cost effectiveness evaluation of fixed guideway system options. Cost effectiveness indices utilized total annualized costs for the options, including both annual operation, maintenance and capital costs. As such, only direct public financial expenditures and income are considered in this level of cost-effectiveness evaluations. Results are summarized below for each goal area.

Goal 1: Improve Regional Mobility

Table 5.11 summarizes evaluation results for **Objective 1.1 – Increase Transit Usage**. Criteria address total forecast 2020 annual transit trips and transit passenger miles, as well as related cost-effectiveness indices.

Table 5.11
Objective 1.1 – Increase Transit Usage

System Option	2020 Annual Transit Trips (Millions)	2020 Annual Transit Passenger Miles (Millions)	Cost Per Transit Trip	Cost Per Transit Passenger Mile
Plan	**55.42**	**481.89**	**$4.79**	**$0.55**
Express Bus/Busway	59.74	613.53	$7.51	$0.73
Commuter Rail	55.82	498.84	$7.69	$0.86
Light Rail	58.44	532.93	$7.85	$0.86
Automated Rail	56.93	511.34	$8.13	$0.91
Light Rail Plus Commuter Rail	57.88	523.05	$8.39	$0.93
Light Rail Plus Express Bus	57.53	522.74	$7.09	$0.78

Source: MAG, BRW, October 1998

As shown in Table 5.11, the Express Bus/Busway option would result in the highest number of both 2020 annual transit trips and transit passenger miles, followed by the Light Rail option. The Commuter Rail option would result in the lowest number of both 2020 annual transit trips and transit passenger miles. On the basis of cost per transit trip, the Light Rail Plus Express Bus option is most cost-effective. On the basis of cost per transit passenger mile, the Express Bus/Busway option is best. Both the Automated Rail and Light Rail Plus Commuter Rail would be the least cost-effective in addressing the objective of increasing transit usage.

Table 5.12 summarizes evaluation results for **Objective 1.2 – Increase Transit Availability**. Criteria address annual transit revenue miles and cost per transit revenue mile.

Table 5.12
Objective 1.2 – Increase Transit Availability

System Option	Annual Transit Revenue Miles (Millions)	Cost Per Transit Revenue Mile
Plan	**39.03**	**$ 6.80**
Express Bus/Busway	56.30	$ 7.97
Commuter Rail	49.06	$ 8.75
Light Rail	41.59	$11.03
Automated Rail	40.51	$11.43
Light Rail Plus Commuter Rail	41.74	$11.64
Light Rail Plus Express Bus	43.08	$ 9.47

Source: MAG, BRW, October 1998

As shown in Table 5.12, the Express Bus/Busway option provides the highest amount of annual transit revenue service. The Automated Rail and Commuter Rail options provide the least amount of annual transit revenue miles. The Express Bus/Busway option would also be most cost-effective in addressing the objective of increasing transit availability. The Light Rail Plus Commuter Rail would be the least cost-effective in addressing this criteria.

Table 5.13 displays evaluation results for **Objective 1.3 – Increase Traffic Flow**. Criteria address the decrease in system-wide congested lane miles in the PM peak hour compared to the current Long Range Transportation Plan. Congestion was defined as facilities with a peak hour volume/capacity (V/C) ratio greater than 0.90. The cost per decrease in congested PM peak hour lane miles is also shown for each of the options.

Table 5.13
Objective 1.3 – Increase Traffic Flow

System Option	Decrease in Congested PM Peak Hour Lane Miles*	Cost Per Decrease in Congested PM Peak Hour Lane Miles (Million $'s)
Plan	**N/A**	**N/A**
Express Bus/Busway	330	$1.584**
Commuter Rail	80	$5.368
Light Rail	100	$4.586
Automated Rail	120	$3.857
Light Rail Plus Commuter Rail	100	$4.856
Light Rail Plus Express Bus	110	$3.710

* Compared to Plan

Source: MAG, BRW, October 1998

** Includes roadway improvements estimated at 74.14 million (2020 annualized) for Grand Avenue and Freeway HOV lane additions.

As shown in Table 5.13, compared with the existing Plan, the Express Bus/Bus option results in the largest decrease in congested lanes miles. This, however, is primarily due to improvements along Grand Avenue along with freeway HOV lane additions. Of the remaining options, the Automated Rail and Light Rail Plus Express Bus options provide the highest level of congestion relief. As noted previously, any reduction in roadway lanes to implement any of the options, particularly Light Rail, has not been included. The rail options, however, are also likely to provide higher levels of congestion relief in specific travel corridors.

On a cost-effectiveness basis, the Express Bus/Busway option provides the highest congestion reduction per unit of cost, followed by the Light Rail Plus Express Bus option. The Light Rail Plus Commuter Rail and Commuter Rail options would generally be the least cost-effective in providing congestion relief and necessary traffic flow.

Table 5.14 summarizes evaluation results for **Objective 1.4 – Reduce Auto Dependence**. Criteria address both the change in transit mode share relative to the existing Plan and 2020 annual VMT reduction relative to the existing Plan. Related cost-effective measures are also displayed.

Table 5.14
Objective 1.4 – Reduce Auto Dependence

System Option	Year 2020 Change in Transit Mode Share*	Annual VMT Reduction* (Millions)	Cost Per Increase in Transit Mode Share (Million $'s)	Cost Per Decrease in VMT*
Plan	**N/A**	**N/A**	**N/A**	**N/A**
Express Bus/Busway	0.11%	123.043	$4077.255	$4.25**
Commuter Rail	0.01%	284.841	$42947.700	$1.51
Light Rail	0.07%	340.766	$6551.129	$1.35
Automated Rail	0.04%	277.613	$11570.550	$ 1.67
Light Rail Plus Commuter Rail	0.06%	330.732	$8094.050	$ 1.47
Light Rail Plus Express Bus	0.05%	352.955	$8162.740	$ 1.16

* Compared to Plan
Source: MAG, BRW, October 1998
** Includes $74.14 Million (Annualized) for Grand Avenue Busway

As shown in table 5.14, the Express Bus/Busway option would result in the largest increase in transit mode share relative to the existing Plan, followed by the Light Rail option. The Commuter Rail option would provide the smallest increase in transit mode share for the region.

In a similar manner, the Light Rail Plus Express Bus option would provide for the largest reduction in 2020 annual VMT. The Express Bus/Busway option would have the least impact on regional VMT.

On a cost-effectiveness basis, the Express Bus/Busway option would be the most cost-effective in increasing the regional transit mode share. The Commuter Rail option would be the least cost-effective in increasing the transit mode share.

The Light Rail Plus Express Bus option would result in the lowest total cost per decrease in annual VMT. The Express Bus/Busway option would result in the highest cost per decrease in VMT.

Goal 2: Minimize Impacts on the Environment

Table 5.15 displays evaluation results for **Objective 2.1 – Improve Air Quality**. Criteria address both the decreases in system-wide congested PM peak hour lane miles and annual VMT relative to the existing Plan. Both factors relate directly to the resulting magnitude of vehicular emissions. Related cost-effectiveness indices are also displayed.

Table 5.15
Objective 2.1 – Improve Air Quality

Alternative	Decrease in Congested PM Peak Hour Lane Miles *	2020 Annual VMT Reduction* (Millions)	Cost Per Decrease in Congested PM Peak Hour Lane Miles (Million $'s)	Cost Per Decrease in VMT*
Plan	**N/A**	**N/A**	**N/A**	**N/A**
Express Bus/Busway	330	123.043	$1.584**	$4.25**
Commuter Rail	80	284.841	$5.368	$1.51
Light Rail	100	340.766	$4.586	$1.35
Automated Rail	120	277.613	$3.857	$1.67
Light Rail Plus Commuter Rail	100	330.732	$4.856	$1.47
Light Rail Plus Express Bus	110	352.955	$3.710	$1.16

* Compared to Plan
Source: MAG, BRW, October 1998
** Includes $74.14 Million (Annualized) for Grand Avenue Busway

As shown in Table 5.15, compared with the existing Plan, the Express Bus/Busway option would provide for the largest reduction in congested PM peak hour lane miles. The same option, however, shows the smallest decrease in annual VMT, creating a trade-off in air quality benefits. While resulting in a relatively moderate decrease in congestion, the Light Rail Plus Express Bus option would result in the largest reduction in year 2020 Annual VMT and therefore, maximizing air quality benefits.

Table 5.16 summarizes evaluation results for **Objective 2.2 – Reduce Energy Dependence**. Criteria address 2020 annual VMT reduction relative to the existing Plan and the cost per VMT reduction.

Table 5.16
Objective 2.2 – Reduce Energy Dependence

Alternative	2020 Annual VMT Reduction * (Million)	Cost Per Decrease in Annual VMT
Plan	**N/A**	**N/A**
Express Bus/Busway	123.043	$4.25**
Commuter Rail	284.841	$1.51
Light Rail	340.766	$1.35
Automated Rail	277.613	$1.67
Light Rail Plus Commuter Rail	330.732	$1.47
Light Rail Plus Express Bus	352.955	$1.16

* Compared to Plan
Source: MAG, BRW, October 1998
** Includes 74.14 Million (Annualized) for Grand Ave. Busway

As shown in Table 5.16, compared with the existing Plan, the Light Rail Plus Express Bus option would provide the largest reduction in annual VMT, resulting in energy savings. The Express

Bus/Busway option would provide the least VMT reduction, compared to the other options. On a cost-effectiveness basis, the Light Rail Plus Express Bus option would provide maximum energy savings at the lowest cost.

Table 5.17 summarizes evaluation results for **Objective 2.3 – Core Development Support**. Criteria address the number of annual transit trips to the Central Downtown area and related cost-effectiveness indices.

Table 5.17
Objective 2.3 – Core Development Support

Alternative	Annual 2020 Transit Trips in Central CBD (Million)	Cost Per Transit Trip in Central CBD
Plan	**5.255**	**$50.52**
Express Bus/Busway	5.822	$77.03
Commuter Rail	5.278	$81.37
Light Rail	6.038	$75.94
Automated Rail	5.721	$80.90
Light Rail Plus Commuter Rail	5.921	$82.02
Light Rail Plus Express Bus	5.917	$68.98

Source: MAG, BRW, October 1998

As shown in Table 6.7, the Light Rail option would result in the highest number of transit trips the Central CBD, followed by the Light Rail Plus Commuter Rail and Light Rail Plus Express Bus options. The Light Rail Plus Express Bus option would be most cost-effective in terms of the cost per CBD transit trip.

Goal 3: Support Community Social and Economic Goals

Table 5.18 displays the evaluation results for **Objective 3.1 – Provide Access to Jobs**. Criteria address annual transit work trips and the related cost-effectiveness indices.

Table 5.18
Objective 3.1 – Provide Access to Jobs

Alternative	Annual 2020 Transit Work Trips (Millions)	Cost Per Transit Work Trip
Plan	**18.70**	**$14.20**
Express Bus/Busway	22.760	$19.71
Commuter Rail	19.516	$22.01
Light Rail	21.294	$21.54
Automated Rail	20.041	$23.09
Light Rail Plus Commuter Rail	21.029	$23.09
Light Rail Plus Express Bus	20.797	$19.62

Source: MAG, BRW, October 1998

As shown in Table 5.18, the Express Bus/Busway option results in the highest number of annual transit work trips, followed by the Light Rail option. The Commuter Rail option results in the lowest number of annual transit work trips.

On a cost per transit work trip, the Light Rail Plus Express Bus option is most cost-effective. The Automated Rail and Light Rail Plus Commuter Rail options would be the least cost-effective on a cost per transit work trip basis.

Table 5.19 summarizes evaluation results for **Objective 3.2 – Enhance Service to Lower Income Households**. Criteria address the number of annual transit trips from lower income household and the cost per low income transit trip.

Table 5.19
Objective 3.2 – Enhance Service to Lower Income Households

Alternative	Annual 2020 Transit Trips from Lower Income Households (Millions)	Cost Per Transit Trip from Lower Income Households
Plan	**22.52**	**$11.79**
Express Bus/Busway	23.549	$19.05
Commuter Rail	22.494	$19.09
Light Rail	23.098	$19.85
Automated Rail	22.970	$20.15
Light Rail Plus Commuter Rail	22.820	$21.28
Light Rail Plus Express Bus	22.960	$17.78

Source: MAG, BRW, October 1998

As shown in Table 5.19, the Enhanced Bus/Busway option would result in the highest number of transit trips from lower income households. The Commuter Rail option would service the lowest number of lower income trips. On a cost-effectiveness basis, the Light Rail Plus Express Bus option would result in the lowest cost per lower income transit.

Goal 4: Maximize Financial Visibility

Tables 5.20 and **5.21** summarize evaluation results **for Objective 4.1 – Enhance Local Funding Feasibility** and **Objective 4.2 – Enhanced Federal Funding Feasibility**, respectively from the perspective that the greater the proportion of operational costs, the more "feasible" from a local funding basis. In a similar manner, the greater the proportion of capital costs, the more "feasible" from a federal funding perspective.

Table 5.20
Objective 4.1 – Enhance Local Funding Feasibility

Alternative	Total 2020 Annualized Operating Costs (Million of 1998 $'s)	Operating Costs as Percent of Total Costs
Plan	**$146.663**	**55.2%**
Express Bus/Busway	$204.623*	45.6%
Commuter Rail	$154.536	36.0%
Light Rail	$166.502	36.3%
Automated Rail	$159.852	34.5%
Light Rail Plus Commuter Rail	$166.366	34.3%
Light Rail Plus Express Bus	$169.779	41.6%

Source: MAG, BRW, October 1998

* Does not include roadway improvements estimated at 74.14 annualized million (2020) for Grand Avenue and Freeway HOV lane additions.

Table 5.21
Objective 4.2 – Enhance Federal Funding Feasibility

Alternative	Total 2020 Annualized Capital Costs (Million of 1998 $'s)	Capital Costs as Percent of Total Costs
Plan	**$118.805**	**44.8%**
Express Bus/Busway	$243.875 *	54.4%
Commuter Rail	$274.941	64.0%
Light Rail	$292.077	63.7%
Automated Rail	$302.970	65.5%
Light Rail Plus Commuter Rail	$319.277	65.7%
Light Rail Plus Express Bus	$238.358	58.4%

Source: MAG, BRW, October 1998

* Does not include roadway improvements estimated at 74.14 annualized million (2020) for Grand Avenue and Freeway HOV lane additions.

As shown in Table 5.20, the Express Bus/Busway option has both the highest operating cost requirements and the highest percent of operating costs of total costs. While the higher proportion of operating costs may enhance the feasibility of local funding, the downside is that the high operating costs would, require more local funding. The Commuter Rail option requires the lowest operating costs, while the Light Rail Plus Commuter Rail results in the lowest percent of operating costs of total costs.

As shown in Table 5.21, the Light Rail Plus Commuter Rail option would result in the highest capital costs, as well as capital costs as a percent of total costs. The Light Rail Plus Express Bus option has the lowest capital costs.

Tables 5.22 and **5.23** summarize, respectively, evaluation results **for Objective 4.3 – Ensure Long Term Capital Value** and **Objective 4.4 – Maximize Flexibility to Adjust to Change**. The basic premise concludes that a higher proportion of capital costs would provide opportunities to create capital value over the long term. Conversely, a lower capital investment, reflected in a higher proportion of operating costs, would maximize the flexibility to adjust to changing conditions over the long term.

Table 5.22
Objective 4.3 – Ensure Long Term Capital Value

Alternative	Total 2020 Annualized Capital Costs (Million of 1998 $'s)	Capital Costs as Percent of Total Costs
Plan	**$110.410**	**44.8%**
Express Bus/Busway	$243.875 *	54.4%
Commuter Rail	$274.941	64.0%
Light Rail	$292.077	63.7%
Automated Rail	$302.970	65.5%
Light Rail Plus Commuter Rail	$319.277	65.7%
Light Rail Plus Express Bus	$238.358	58.4%

Source: MAG, BRW, October 1998

* Does not include roadway improvements estimated at 74.14 annualized million (2020) for Grand Avenue and Freeway HOV lane additions.

Table 5.23
Objective 4.4 – Maximize Flexibility to Adjust to Change

Alternative	Total 2020 Annualized Operating Costs (Million of 1998 $'s)	Operating Costs as Percent of Total Costs
Plan	**$133.997**	**55.2%**
Express Bus/Busway	$204.623*	45.6%
Commuter Rail	$154.536	36.0%
Light Rail	$166.502	36.3%
Automated Rail	$159.852	34.5%
Light Rail Plus Commuter Rail	$166.366	34.3%
Light Rail Plus Express Bus	$169.779	41.6%

Source: MAG, BRW, October 1998

* Does not include roadway improvements estimated at 74.14 annualized million (2020) for Grand Avenue and Freeway HOV lane additions.

As shown in Table 5.22, the Light Rail Plus Commuter Rail results in both the highest 2020 annualized capital costs, as well as capital costs as a percent of total costs. The Light Rail Plus Express Bus option has the lowest capital costs.

Review of Table 5.23 indicates, that the Express Bus/Busway option has the highest operating costs, as well as, operating costs as a percent of total costs.

Table 5.24 displays the evaluation results **for Objective 4.5 – Maximize Transit Farebox Recovery**. The evaluation criteria for this objective focuses on the efficiency of transit usage as measured by the number of transit boardings per transit revenue mile. Higher usage for a given level of service will maximize revenue potential and the proportion of operating costs covered by farebox revenue.

Table 5.24
Objective 4.5 – Maximize Transit Farebox Recovery

Alternative	Total Annual 2020 Transit Boardings Per Transit Revenue Mile
Plan	**2.39**
Express Bus/Busway	1.90
Commuter Rail	1.91
Light Rail	2.31
Automated Rail	2.35
Light Rail Plus Commuter Rail	2.28
Light Rail Plus Express Bus	2.26

Source: MAG, BRW, October 1998

As shown in Table 6.14, the Automated Rail option would result in the highest number of transit boardings per transit revenue mile, followed by the Light Rail option. Both these options provide more concentrated service compared to the other options. The Express Bus/Busway option would have the lowest number of transit boardings per transit revenue mile.

5.7 Conclusions

This section provides a summary of key findings from the evaluation of the various Fixed Guideway System options. **Table 5.25** provides a summary of the performance evaluation. Each of the options were rated either good, moderate, or poor for each of the performance objectives, based upon a comparative assessment of the options.

Key conclusions and observations from the evaluation process are listed below by evaluation criterion.

Mobility

- On a cost per unit basis, the Light Rail option would result in the highest number of annual transit trips, while the Express Bus/Busway option would serve the most transit passenger miles.
- The Light Rail Plus Express Bus option is most cost–effective in increasing transit usage.
- The Express Bus/Busway option is the most cost-effective in providing transit service with the Light Rail Plus Express Bus option being the next best.
- With freeway improvements included the Express Bus/Busway option rates best in reducing congestion, followed by the Light Rail Plus Express Bus option.
- The Light Rail Plus Express Bus options perform best in reducing travel, with the Express Bus/Busway option performing the worst.

Table 5.25
Performance Evaluation Summary

	Express Bus/ Busway	Commuter Rail	Light Rail	Automated Rail	Lt. Rail Plus Commuter Rail	Lt. Rail Plus Express Rail
MOBILITY						
Increased Transit Use	●	◑	◑	○	○	●
Increased Transit Availability	●	◑	◑	○	○	●
Increase Traffic Flow	●	○	◑	◑	○	●
Reduce Auto Dependence	○	◑	●	○	◑	●
ENVIRONMENT						
Air Quality Improvement	◑	○	◑	○	○	●
Energy Savings	○	◑	●	○	◑	●
SOCIAL/ECONOMIC						
Core Development Support	◑	○	●	●	○	●
Service to jobs	◑	◑	◑	○	○	●
Service to Lower Income	◑	◑	◑	○	○	●
FINANCIAL						
Local Funding	●	◑	◑	○	○	◑
Federal Funding	○	●	●	●	●	◑
Long Term Value	○	●	●	●	●	◑
Future Flexibility	●	◑	◑	○	○	◑
Fare Box Recovery	○	●	●	●	◑	◑

Good ● Moderate ◑ Poor ○

Environment

- The Light Rail Plus Express Bus option would maximize both air quality and energy benefits, primarily due to reduced regional VMT.
- The Light Rail Plus Commuter Rail, along with Automated Rail would be the least cost-effective in the addressing environmental criteria.

Social/Economic

- The Light Rail Plus Express Bus option is the most cost-effective in supporting core development and providing regional access to jobs.

- The Light Rail Plus Express Bus option would be the most cost-effective in serving transit trips from lower income households.
- The Commuter Rail and Automated Rail options would be the least cost-effective in addressing the social and economic criteria.

Financial

- The Express Bus/Busway option best achieves the local funding and flexibility objectives due to lower percentages of capital cost requirements (if road costs are excluded).
- The Light Rail Plus Commuter Rail and Automated Rail options, followed closely by the various rail options, best achieve the federal funding and capital value components of the financial objectives, due to higher percentages of capital cost requirements.
- The Automated Rail option, with the highest number of transit boardings per revenue miles, is the most efficient in terms of maximizing transit farebox recovery of operating costs. The Express Bus/Busway option is the least efficient in terms of the number of transit boardings per revenue mile.

5.8 Summary

This section provides a summary of each of the Fixed Guideway System Options, focusing on the goals and performance objectives.

Express Bus/Busway

This option addresses the needs of peak period, longer distance commuters by focusing service on collecting passengers in outlying areas and providing express access to activity centers. The option includes a five-fold increase in revenue miles of express bus service above planned conditions. This option also includes 22 new on-line bus stations, numerous new park-and-ride lots, 48 lane miles of new HOV lanes and upgrading of Grand Avenue to a grade-separated expressway and busway concept with HOV lanes and bus stations every mile.

The Express Bus/Busway option is second best in providing a cost-effective approach to expanding transit services and attracting new transit riders. It rates best in congestion relief primarily due to added HOV freeway facilities. This option, however, rates poorly in reducing overall regional VMT and achieving related environmental objectives. Relative to the other options, it rates moderately in achieving social and economic goals and would have relatively poor transit farebox recover potential.

Commuter Rail

This option provides peak period commuter rail service on all major rail lines in the Valley and would service longer distance trips by suburban commuters who work in central areas. Because stops are further apart, transfers between the commuter rail and local bus are required in central areas, while auto and local bus access is needed in outlying areas.

The Commuter Rail option provides a relatively moderate cost-effective approach to the expansion of transit services and attraction of new transit riders. This option is the least effective in providing congestion relief, while moderately effective at reducing regional VMT, auto dependence, and achieving related environmental objectives. The Commuter Rail option performs poorly in attracting CDB transit trips, as well as providing transit service to lower income households. The option performs relatively good in maximizing potential transit farebox recovery.

Light Rail

This option includes a 68-mile-at-grade light rail transit system. The option includes 12 miles of support circulation routes, with reconfiguration of local bus services to feed light rail stations.

The Light Rail option provides a moderately cost-effective approach to the expansion of transit services and attraction of new transit riders. The option is also moderately cost-effective in reducing congestion; is good at reducing annual VMT and achieving related environmental objectives. The Light Rail option is also moderately cost-effective at providing transit service to jobs and lower income households. This option has the second highest (following Automated Rail) number of transit boardings per transit revenue mile and resulting good potential to maximize transit farebox recovery.

Automated Rail

This option includes 31 miles of fully grade-separated light rail. In a similar manner to light rail, bus routes have been reconfigured to serve stations and downtown circulators have been included to facilitate access in central areas.

The Automated Rail option results in one of the least cost-effective approaches to increasing regional transit service and attracting new transit riders. It performs moderately effective in reducing congestion, and relatively poor in reducing annual VMT. As a result, it generally performs poorly in achieving the related environmental objective. The Automated Rail option also performs poorly in providing transit service to jobs and in serving lower income households. This option has the second highest annual operating costs as a percent of total annualized cost, while having the highest potential transit farebox recovery, as represented by the number of transit boardings per transit revenue mile.

Light Rail Plus Commuter Rail

This option combines the Light Rail and Commuter Rail options with limited light rail service (service to East Valley, south of Southern was deleted) and peak period/peak direction commuter rail service on the Union Pacific line. Local bus, express bus and circulator bus services were also adjusted to avoid duplication and serve rail stations.

The Light Rail Plus Commuter Rail option rates as the least cost-effective approach to providing expanded transit services and attracting new transit riders. It also rates poor in congestion relief and in reducing annual VMT, and as a result, performs poorly in achieving the environmental objectives. In addition, this option is least effective in attracting CBD transit trips, as well as

providing transit service to jobs and lower income households. This option is also the most expensive of the Fixed Guideway System options which were analyzed. This option would have a moderate level of transit farebox recovery potential.

Light Rail Plus Express Bus

This option combines limited light rail service from the Light Rail option with expanded express bus services. Light rail lines were terminated at major park-and-ride lots just beyond activity centers. Express bus service would be provided during the peak period, in the peak travel direction.

The Light Rail Plus Express Bus option is the most cost-effective approach to providing expanded transit services and attracting new transit riders. It also rates high in reducing congestion and reducing annual VMT, and achieving the related environmental objectives. The Light Rail Plus Express Bus option ranks best in providing transit service to CBD trips, service to jobs and lower income households. The option would provide moderate potential to maximize transit farebox recovery.

6.0 Recommendation For a Fixed Guideway Transit Concept

6.1 Overview

This Study has focused on fixed guideway transit options including routes and technologies. This section develops a fixed guideway transit concept as input to ongoing efforts to update the MAG Long Range Transit Plan.

System Elements. The basis of the recommended concept is the Light Rail Plus Express Bus Option as developed in Section 5.0. It includes a doubling of local bus service, a light rail transit (LRT) system and expanded express bus service. In a broader context, the proposed multimodal concept includes the following elements.

- A 39-mile light rail transit (LRT) system (or equivalent bus option) focused on serving central activity centers. Potential future extensions to Peoria, Scottsdale, Chandler and the Deer Valley Village core have also been identified.
- Expansion of express bus service to connect outlying areas to central activity centers. The manner and extent to which express buses circulate within residential and employment areas will be addressed in future studies.
- A tripling of local bus service to provide transit mobility throughout the urbanized area. This will include incorporating all local transit plans as developed by the RPTA and the local jurisdictions.
- A major expansion of downtown circulators to expand the service areas of express bus and light rail services.
- Commuter bus connections to outlying communities.
- Improvements to bus stops including shelters and bus pullouts.
- A tripling of Dial-a-Ride service to meet paratransit transportation needs.

Funding Concept. A variety of funding strategies could be developed to support the proposed fixed guideway concept (Light Rail Plus Express Bus Option), each involving some combination of funds from the following types of sources:

- Federal formula and discretionary grant programs;
- State discretionary transportation funds;
- Regional (countywide) dedicated revenue mechanism (sales tax or other);
- Local (city and county) dedicated revenue mechanisms (sales tax and/or other);
- Local (city and county) discretionary funds; and
- Private sector contributions.

In general the combined total systemwide capital and operating cost of the proposed concept over 21 years (to 2020) could be covered with the revenue equivalent to a 0.65% countywide sales tax over that same period. In reality, as much a 40 percent of the total funding need could be met from sources other than local and regional sales taxes, potentially including:

- Transit Fares
- Federal Discretionary Rail "New Start" Funds
- Federal Formula transit Assistance Funds
- MAG/Federal CMAQ Funds
- Arizona LTAF Funds
- Local General Funds

Under this scenario, the required contribution from some combination of dedicated regional and local taxes would be reduced to the equivalent of a 0.4% countywide tax.

Guiding Principals. The proposed transit concept is based on an underlying set of principals. These include:

- Comprehensive. No one transit technology can meet all needs. A combination of approaches is needed best to meet regional needs.
- Central Service. As the land use patterns mature and densities increase, it becomes increasingly difficult to meet transportation needs with automobile options in central areas. Therefore, transit solutions are focused on serving central areas--especially central activity centers.
- Coverage. Transit coverage throughout the metropolitan area is important in order to provide basic transit access to jobs and other needs throughout the region.
- Special Needs. Transit is especially important to meet the transportation needs of those who are unable to drive.
- Congestion. Transit is part of a package to address congestion. Accordingly transit service needs to target congested corridors, support high occupancy vehicle facilities and provide car-poolers alternatives when their rides are not available.
- Air Quality. Transit is part of a package with other demand management tools to reduce auto travel and improve air quality.
- Funding. A degree of equity is needed between where funds are raised and where they are expended.

6.2 System Elements

Light Rail. The proposed light rail transit (LRT) concept is focused on the central area and serves the downtown areas of Glendale, Phoenix, Tempe and Mesa with spurs to the Metro

Center area and Rio Salado (see **Figure 6-1**). Another logical terminus is the downtown Scottsdale area. This area is not included at this time because of limited funding prospect, however, the Rio Salado spur could be extended to the Scottsdale area in the future if funding prospects become more favorable. Similarly, the LRT system could be extended to downtown Chandler, downtown Peoria, and the Deer Valley Village core if funds are forthcoming.

The concept is a 39-mile at grade light rail system with stations generally every mile. Stations would be more frequent in central areas, and most outlying stations would have parking facilities. A major park-and-ride lot is envisioned at the end of each line.

Frequency of service on the central facility (Glendale and 19th Avenue to downtown Tempe) proposed as every five minutes during peak travel periods--five days per week. On the extensions the proposed weekday peak period service would be every ten minutes. Service would be provided 19 hours on weekdays and 17 hours on Saturdays, Sundays and holidays. The off-peak frequency would be cut in half. Further analysis is needed to balance frequencies and demand.

The concept is to support economic development and denser land use patterns in central activity centers. Reductions in vehicle miles of travel could be offset by higher traffic densities, signal preemption, and loss of traffic lanes.

Other transit modes would be adjusted to better support LRT. All stations would be served by local bus service with minor adjustments to the local bus grid. Directly competing local bus service such as the Red Line would be discontinued.

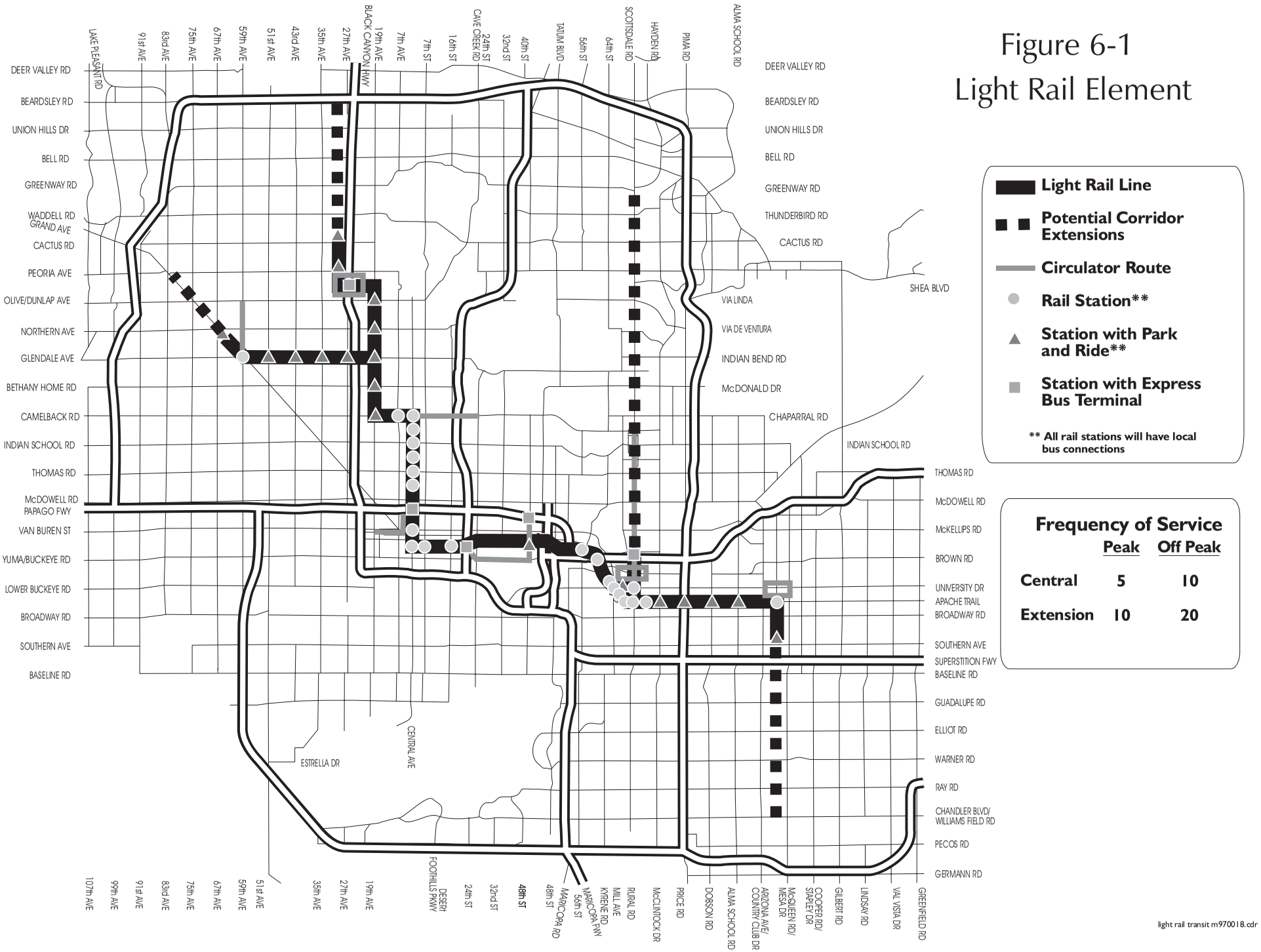
Five on-line express bus terminals are proposed that would interface with the LRT system. These include downtown Phoenix, downtown Tempe, the Metro Center area, and two airport stations. High frequency shuttle service is targeted for downtown areas to expand the service area of the LRT and express buses.

The light rail transit concept is in the process of being refined. Major Investment Studies (MIS) have been completed for both the Central Phoenix/East Valley, and the Phoenix/Glendale Corridors.

An alternative technology is bus rapid transit (BRT). This concept performs in a similar way as LRT except buses rather than rail vehicles are used. Costs are lower and flexibility is higher because tracks and electric lines are not needed. This technology warrants further consideration in proposed LRT corridors. A BRT option has been considered in the Central Phoenix/East Valley rail corridor and LRT was recommended. In the Phoenix/Glendale MIS, LRT and BRT have both been studied.

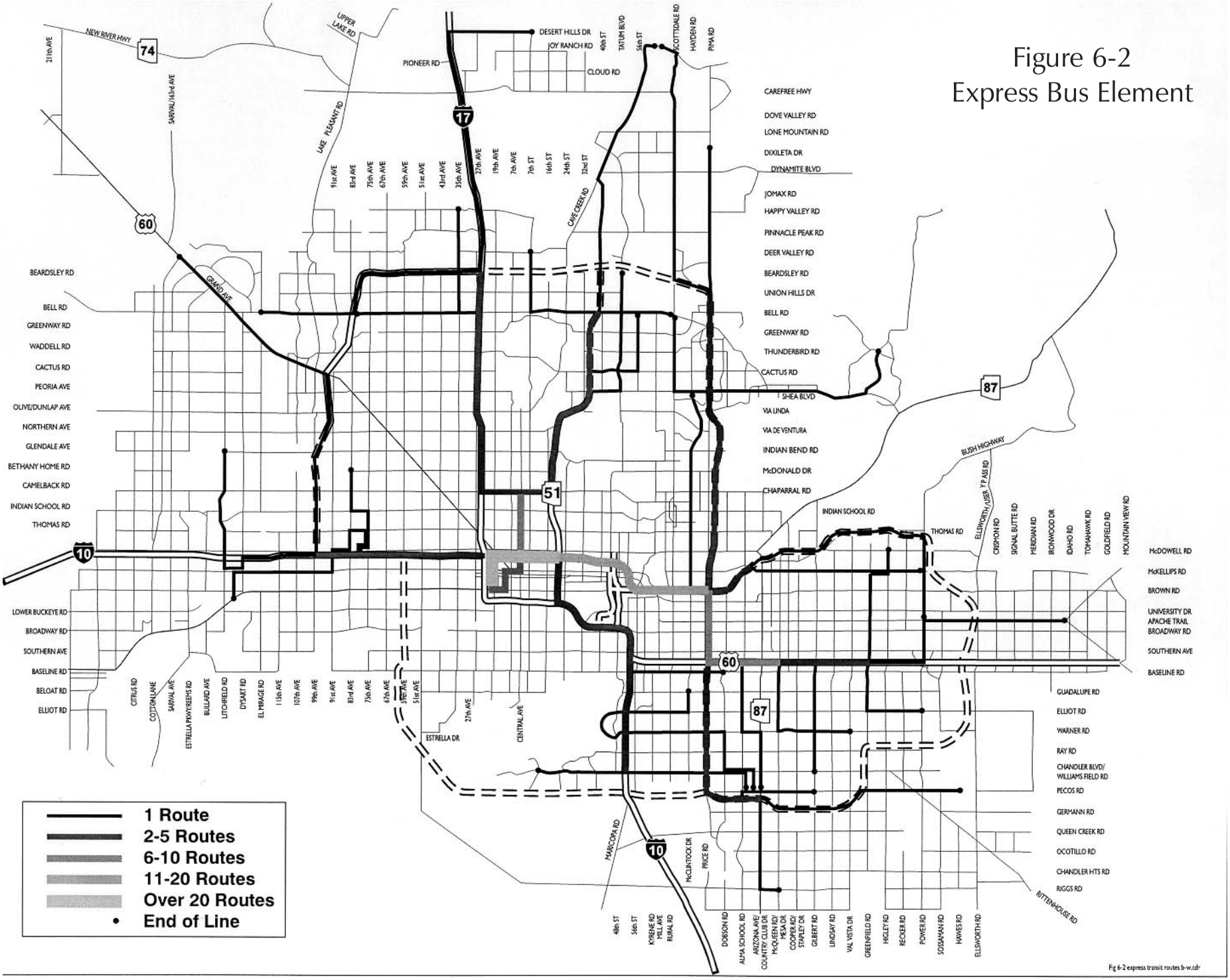
Express Bus. The express bus system focuses on connecting outer portions of the urbanized area to central activity centers. It is focused on work trips in the peak period and peak direction to reduce congestion (see **Figure 6-2**).

Figure 6-1
Light Rail Element



light rail transit m970018.cdr

Figure 6-2
Express Bus Element



The proposed express system more than doubles the miles of express bus service by 2010, and by 2020 the service is nearly quadrupled. The system has also been adjusted to compliment the light rail system. Express bus service is not provided in areas serviced by light rail, while express service in non-LRT corridors has been intensified.

The operating plan for the express bus system is similar to that which exists today. Buses circulate in outlying areas serving neighborhoods and park-and-ride lots. The express bus then enters a freeway and travels to centrally located employment destinations. Freeway plans call for HOV lanes in most express corridors and an increase in the number of park-and-ride lots. The proposed concept also includes five new on-line express bus stations which would also interface with the LRT system.

The proposed express service would be only in one direction, only in peak periods and only on weekdays. The proposed frequency is every 30 minutes, eight hours per day. Actual frequency and periods would need to be adjusted based on demand.

Alternative express bus concepts are being studied. The ultimate concept for express bus service is under study and could reshape service in outlying areas by serving park-and-ride lots rather than circulating in neighborhoods. Also, a Value Lane Study will assess HOV and HOT concepts, while a Grand Avenue MIS will address express bus and busway options. Outstanding issues include:

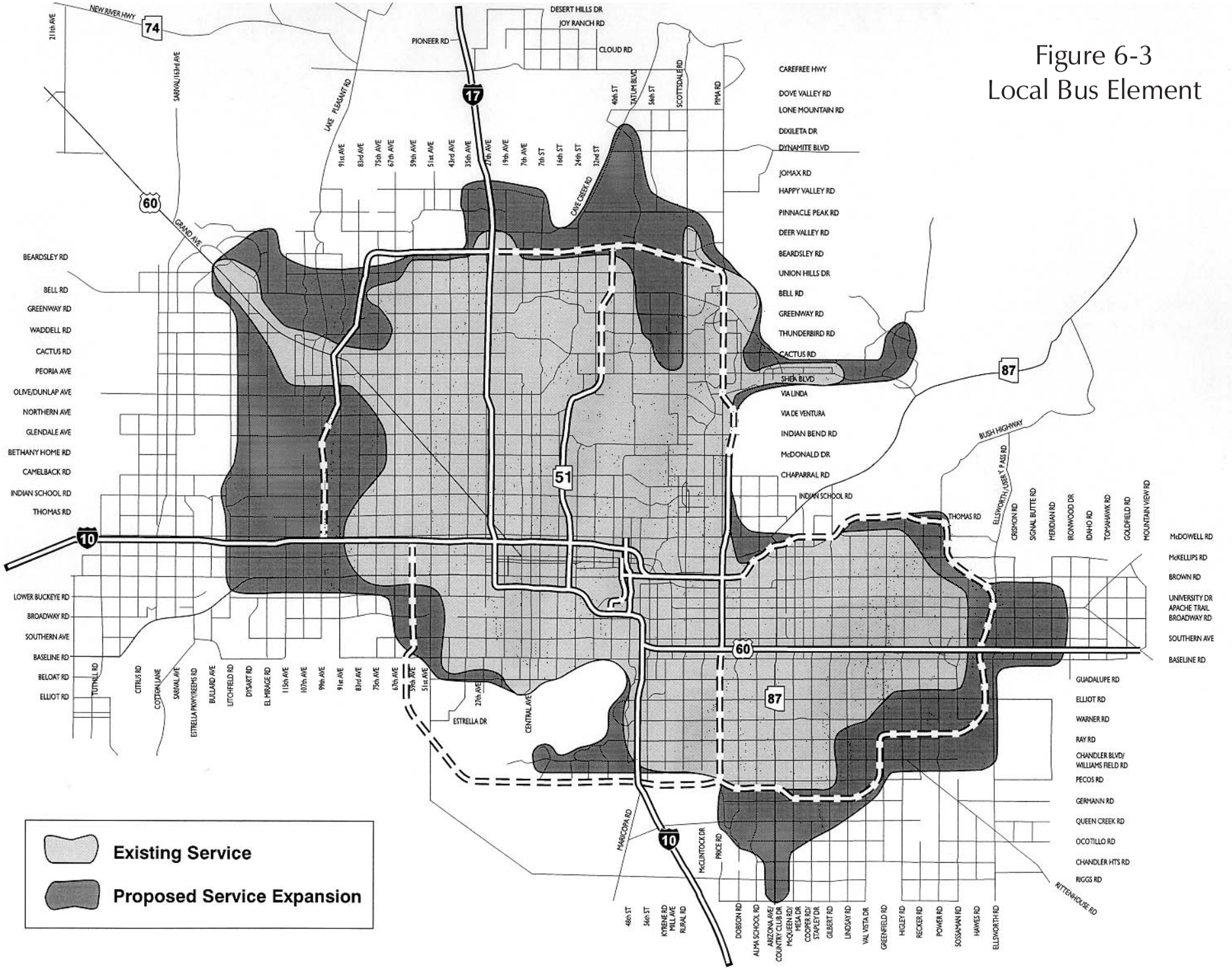
- Should circulation in outlying neighborhoods be reduced in favor of more direct service to park-and-ride lots?
- To what extent should buses circulate in employment destinations areas?
- Are express bus terminals worthwhile given the high penalty on transfers?
- Given the need for "dead heading" and "lay overs" associated with the current one way service, are there opportunities to serve reverse commutes?
- What are the needs, location and design concepts for additional park-and-ride lots and stations?
- Are additional HOV lanes and ramps needed?

Local Bus. Local bus service follows the mile grid street system of the Phoenix metropolitan area. It provides basic access to activities throughout the urbanized area for those who do not own and operate a vehicle (see **Figure 6-3**). Approximately 70 percent of those currently riding the public transit system do not have access to a vehicle.

Since 1992 the regional transit plan has been to double bus service. The current concept calls for revenue miles of service to more than double by 2010 and to nearly triple by 2020. The concept includes funding for related support such as, maintenance facilities and customer service. Based on the Phoenix Transit Plan, this concept also upgrades and expands existing vehicles and passenger facilities. Some of these elements include:

- Six new transit centers.

Figure 6-3
Local Bus Element



- Benches at 1/2 of all stops.
- Shelters at 1/4 of all stops.
- Replacement of buses over 12 years of age.

Because of funding limitations, these standards are gradually phased in over the 2000 to 2010 period.

It is proposed that local bus service generally be provided 19 hours per day five days per week and 17 hours per day on Saturdays, Sundays, and Holidays. In most cases, the plan is for buses to operate at a 30 minute frequence in both the peak and off peak periods. In some cases 15 minute service is provided on high demand routes in peak periods, and on low demand routes service is 60 minutes in the off peak. Service on weekends and evenings are approximately half the level of the midday off peak period. Considerable work remains to adjust route frequencies by time of day and demand.

Currently local bus plans are under review and this will lead to an update of the regional transit plan. A number of issues have emerged including:

- Funding equity.
- Spatial coverage versus more service in high demand areas.
- Temporal coverage versus more service in peak periods.
- Facility upgrades versus more service.
- Cost of operations is a key variable that needs to be addressed in more detail.
- Frequency of service by time of day, location, level of demand and route.

Shuttles. The Tempe and Phoenix long range plans include neighborhood circulators. The current regional plan incorporates circulators in downtown areas and Tempe neighborhoods. As indicated in Figure 6-1 circulators in central activity centers have been adjusted and expanded to support the LRT. Circulators extend from the LRT system to support the following areas:

- 59th Avenue Corridor between downtown Glendale and Glendale Community College.
- Camelback corridor from Central Avenue to 24th Street.
- Deck Park Station in downtown Phoenix to the State Capital.
- Sky Harbor Airport.
- Downtown Tempe.
- Downtown Mesa.
- Scottsdale corridor from the LRT in Tempe to downtown Scottsdale.
- Metro Center area.

The frequencies of downtown circulators are generally timed to be consistent with LRT service. Only Tempe has provided specific information on neighborhood circulators. Considerable work remains to define the shuttle concept including:

- The effectiveness of shuttle concepts needs to be assessed.
- The level of shuttle frequencies by time of day needs to be adjusted on individual routes.
- The concept of downtown circulators, currently in the long range plan, needs to be adjusted to more fully integrate with LRT.

Dial-a-Ride. Dial-a-Ride service is designed to meet the needs of those who cannot drive or use fixed route transit service. It largely serves the elderly and disabled. Taxi cabs are an alternative to those who can afford it.

Since 1992, the regional plan has supported tripling Dial-a-Ride service. This plan remains part of the proposed concept with a doubling of service by 2010, and a tripling of service by 2020. Outstanding issues under study include transfers between jurisdictions and slow response times. Low farebox recovery rates are also a concern. A Dial-a-Ride Study is currently underway.

Related Programs. In the funding concept, a set-aside of funds is reserved for programs to meet special transportation needs such as welfare-to-work programs. Also, funds are reserved for transportation demand management activities such as rideshare programs

Commuter Bus Service. Bus service would be provided to all communities in Maricopa County. Express bus service extends to outlying communities such as Queen Creek, Carefree, and Cave Creek. Commuter bus service would be extended to the outlying commuters of Buckeye, Gila Bend and Wickenburg. Commuter bus service would operate similarly to express bus service in that it would operate only on weekdays and during the peak period.

6.3 Funding Concept

The combined total systemwide capital and operating cost of the proposed fixed guideway transit concept recommended for further study (Light Rail Plus Express Bus Option) from the present to the year 2020 totals $7.2 billion in constant 1998 dollars. That amount is equivalent to the revenue yield from a 0.65% countywide sales tax over the same 21-year period. A variety of funding strategies could be developed to support the proposed, each involving some combination of funds from the following types of sources:

- Federal formula and discretionary grant programs;
- State discretionary transportation funds;
- Regional (countywide) dedicated revenue mechanism (sales tax or other);
- Local (city and county) dedicated revenue mechanisms (sales tax and/or other);
- Local (city and county) discretionary funds; and
- Private sector contributions.

Under federal law governing the commitment of federal surface transportation funding assistance, all urban areas are required to maintain adequate long-range transportation plans, including the demonstration of ". . . existing and proposed funding sources that can reasonably be expected to be available." Further, federal regulations require that "proposed new revenue [sources]. . . shall be identified, including strategies for ensuring their availability for proposed investments."

The funding concept for the proposal transit concept includes a combination of existing and proposed new sources of funds, drawing on resources from all levels of government. Federal guidelines on how to demonstrate the "reasonable availability" of future funding make two key suggestions:

1. Existing Sources – Funding from sources that are now available and have been available for some period of time may be extrapolated from past experience over the duration of the planning period.

2. New Sources – The funding plan should identify strategies for ensuring the availability of new funding, including a specific plan of action describing the steps needed to secure any necessary legislation, voter approvals, or multi-agency actions.

Funding Sources

As shown in **Table 6.1**, the funding concept developed for the proposed option suggests that as much as 40 percent of the total funding need could be met from existing federal, state, and local sources. These sources potentially include:

Federal Funds
- Federal Section 5309 Discretionary "New Start" and Bus Capital Funds
- Federal Section 5307 Formula Transit Capital Funds
- MAG/Federal CMAQ Formula Funds
- Federal Section 5310 Formula Funds (Paratransit)

State Funds
- Arizona Local Transportation Assistance (LTAF) Funds
- Public Transportation Assistance (PTA) Funds

Local Funds
- City General Funds
- City Dedicated Funds

User Fees
- Transit Fares

TABLE 6.1
POTENTIAL LONG RANGE TRANSIT FUNDING PLAN (1)
(Constant Dollars in Millions)

ANNUAL REVENUE MILES OF SERVICE (Millions)	FY 1998	FY 2020	TOTAL 1998-2020	SHARE OF SUBTOTAL 1998-2020
Local	13.1	38.7	637.0	65.3%
Express	1.0	3.9	49.3	5.1%
Shuttle	0.0	1.6	22.2	2.3%
Dial-a-Ride	5.5	16.5	242.3	24.9%
Light Rail	0.0	2.3	24.2	2.5%
Total	19.7	63.0	975.0	100.0%
OPERATING COSTS				
Local	46.6	138.3	2,276.6	56.3%
Express	4.9	19.6	253.6	6.3%
Shuttle	0.2	5.5	79.3	2.0%
Dial-A-Ride	9.7	29.0	424.6	10.5%
Light Rail	0.0	26.0	267.6	6.6%
Operations Support (2)	12.2	39.1	604.6	15.0%
Special Needs/TDM (3)	2.0	8.6	137.9	3.4%
Total	75.9	266.1	4,044.4	100.0%
CAPITAL COSTS				
Local Buses	0.0	41.3	571.5	23.2%
Express Buses	6.4	5.2	78.4	3.2%
Shuttle Vehicles	0.0	3.8	64.2	2.6%
Dial-A-Ride Vehicles	8.5	4.2	101.4	4.1%
Light Rail	0.0	30.0	1,170.0	47.5%
Bus Park-and-Ride Lots and Buss Pullouts/Que Hoppers	0.0	9.3	136.2	5.5%
Bus Stations, Centers and Stops	0.0	11.7	125.8	5.1%
Maintenance Facilities and Equipment	3.6	19.1	133.3	5.4%
Other Capital Support (4)	1.6	3.0	93.7	3.8%
Total	20.1	127.6	2,474.5	100.0%
FUNDING (5)				
Local Bus Fares	17.4	34.6	586.5	8.8%
Express Bus Fares	1.8	4.8	62.4	0.9%
Light Rail Transit Fares	0.0	10.4	107.1	1.6%
Shuttle Vehicle Fares	0.1	1.4	20.0	0.3%
Dial-A-Ride Vehicle Fares	0.9	2.7	39.8	0.6%
Local General Funds	22.0	10.0	349.9	5.3%
Local Sales Tax (6)	28.9	113.5	2,059.5	31.1%
Regional Sales Tax (7)	6.9	148.6	1,901.0	28.7%
LTAF	11.9	8.5	267.0	4.0%
Federal Light Rail Transit	0.0	15.0	585.0	8.8%
Federal Bus (Section 3, 8, 9 and 16)	26.4	19.4	509.5	7.7%
MAG CMAQ	5.0	4.0	103.3	1.6%
Other	2.5	1.3	41.3	0.6%
Total	123.7	374.1	6,632.3	100.0%

1. Includes local and regional expenditures for public transportation.
2. Administration, customer service and support vehicle operating costs, security and facility maintenance costs.
3. Includes Travel Demand Management, Rideshare and service to special need populations programs.
4. Includes office space, computer and communications equipment, support vehicle purchases, passenger information systems.
5. Net after bonding.
6. Includes revenue from quarter-cent sales taxes from cities participating in the light rail program.
7. Includes revenue from a quarter-cent countywide sales tax.

With this level of existing funding, the required contribution from new funding sources would be reduced to the equivalent of a 0.4% countywide tax. While local funding mechanisms other than the sales tax are possible, and new contributions from other state sources such as the vehicle license tax (VLT) also are possible, the past several years of planning and policy actions at the regional and local level suggest that the sales tax is the mechanism with greatest level of public and official support. For the purposes of this funding concept, it is assumed that the required resources would be generated from some combination of new dedicated regional and local sales taxes.

Financial Model

The financial analysis in this report is based on a complex and comprehensive transit financial model. It is a very large spreadsheet with costs and revenues by year. Special detailed features of the model include the following:

- Conversion of MAG Transportation Demand Model information by peak and off peak hours to annual estimates.
- Detailed unit cost information.
- Complete analysis of cost and timing of upgrades to the existing system.
- Capability to incorporate Bonding measures.

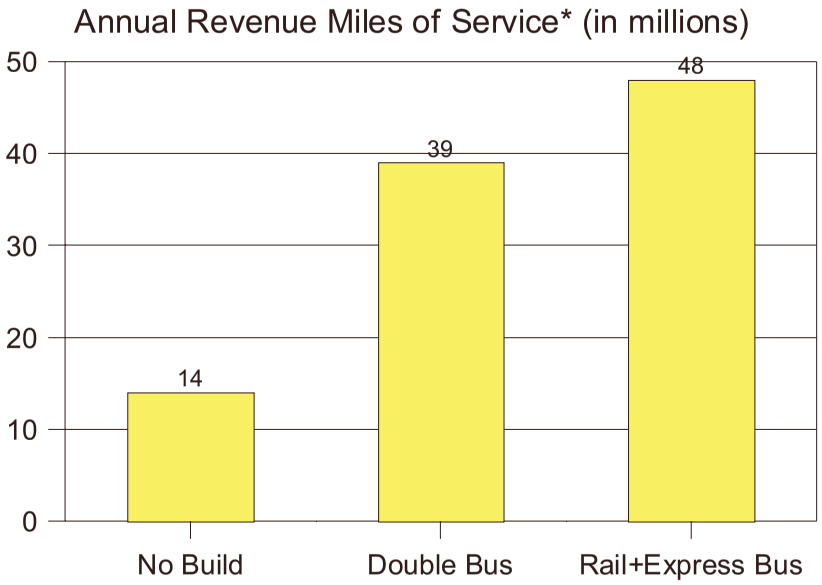
This financial model is a work in progress. Features that are under active consideration at the time of this printing are discussed in **Appendix C**.

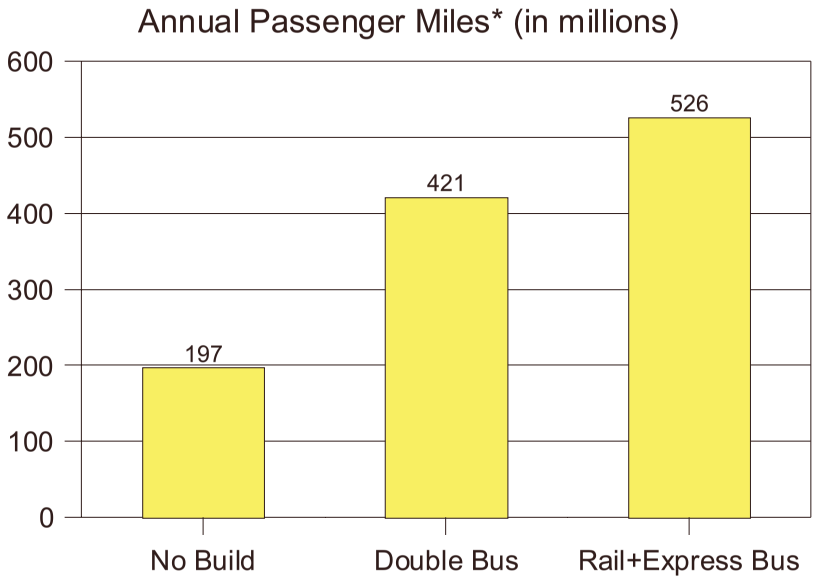
6.4 Performance

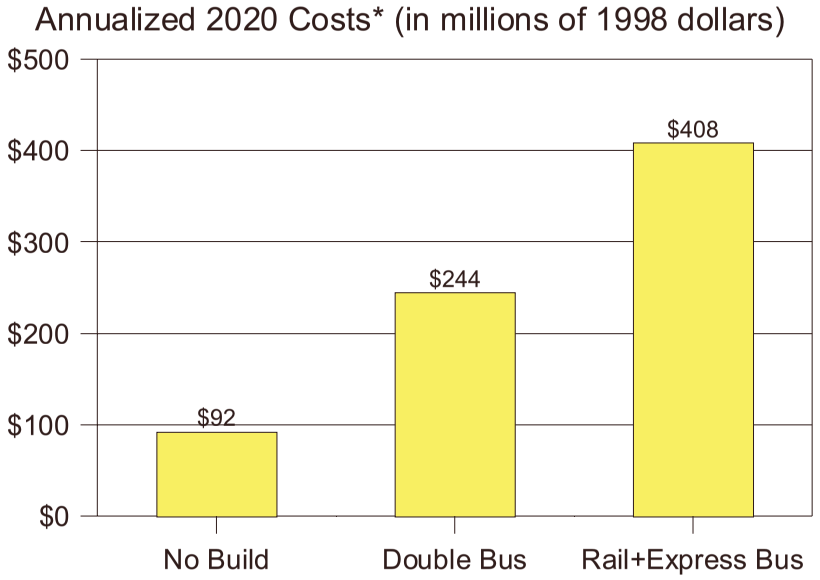
Level of Service. Data on the performance of the Light Rail Plus Express Bus Option is presented in Section 5.0 and is illustrated further in **Figures 6-4** and **6-5**. Compared with today, hours of service on weekdays would be expanded from 15 hours to 19 hours, and peak period service would be expanded from five hours to eight hours. Saturday service would be expanded and regional Sunday service would be established. Overall, revenue miles of service would be increased 230 percent, local bus service would increase 200 percent, express bus service would be increased 300 percent and LRT service would be added.

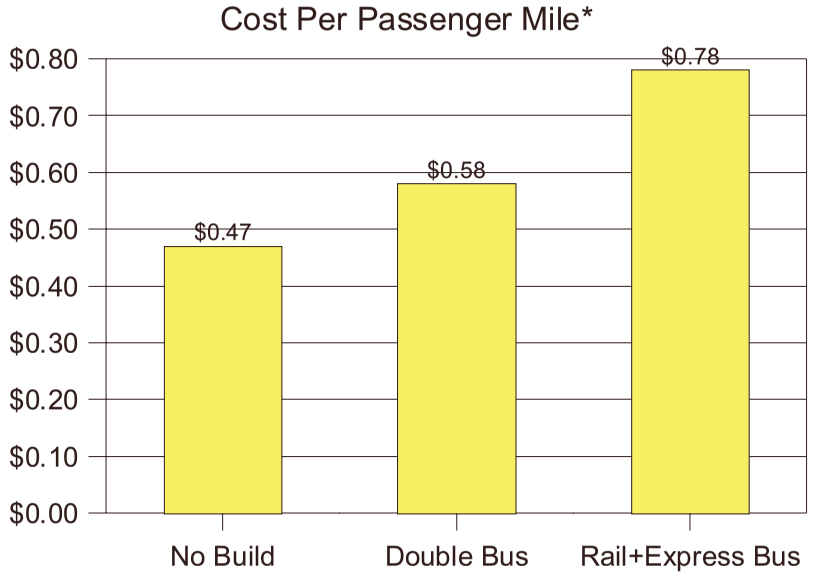
Under the proposed option 83 percent of the revenue miles of service would be local buses--express buses would provide eight percent and rail would provide five percent. However, the load factors on express buses and rail are higher than local buses. As a result, local buses are projected to carry 69 percent of the transit passenger miles, with rail and express buses projected to carry 20 percent and 10 percent respectively.

Figure 6-4: 2020 Comparison of Options: No Build, Double Bus, and Light Rail Plus Express Bus



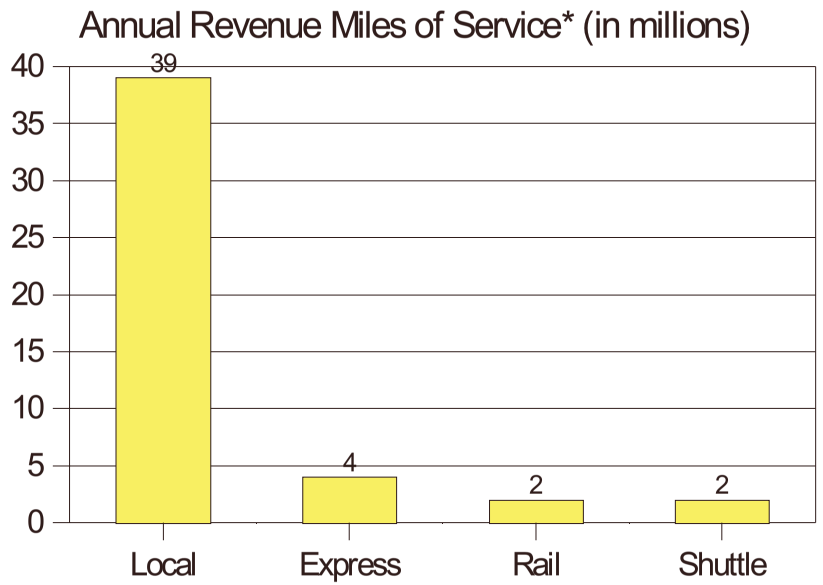


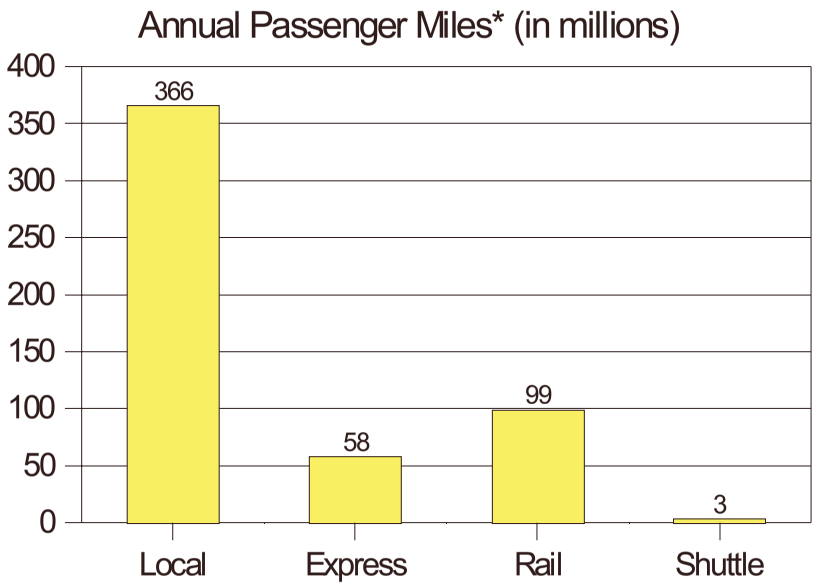


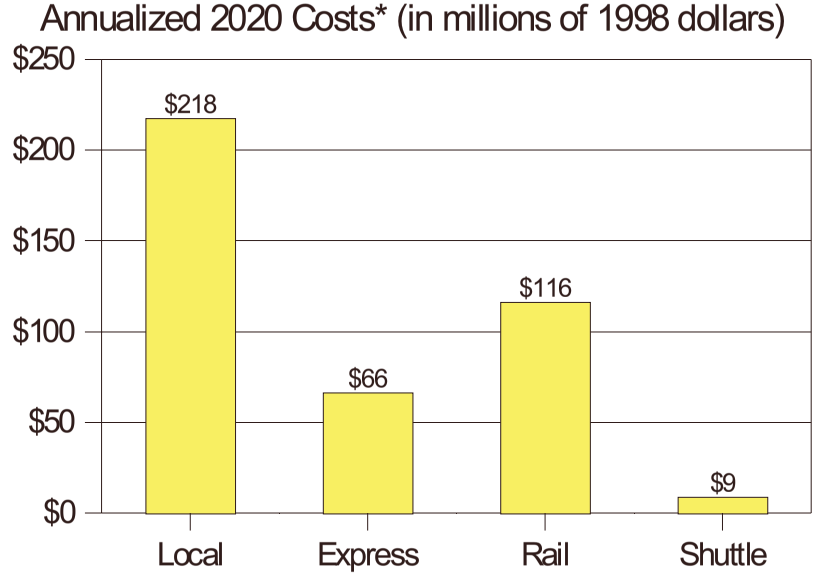


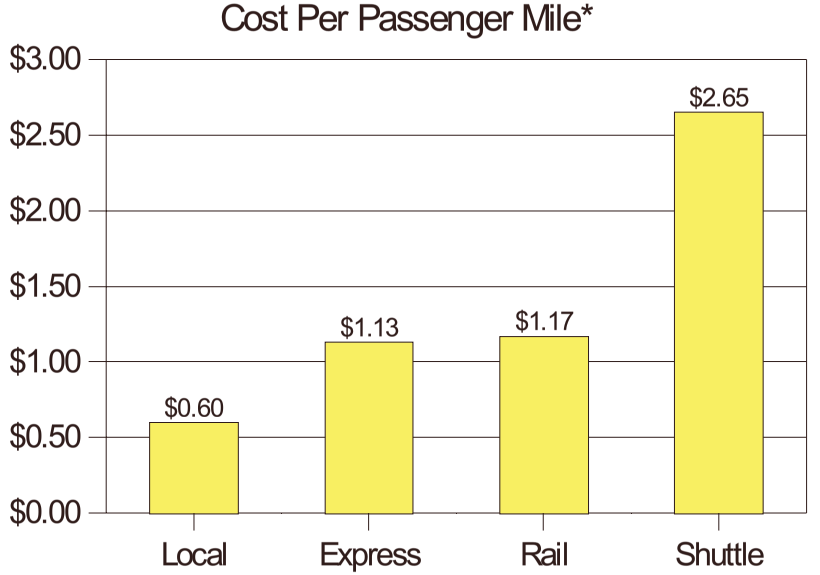
*Does not include Travel Demand Management and Dial-a-Ride programs

Figure 6-5: 2020 Transit Indicators By Mode: Light Rail Plus Express Bus









*Does not include Travel Demand Management and Dial-a-Ride programs

Local Bus. The current bus system is small but efficient. Additional bus service is less cost effective but overall appears to be the most cost effective approach to carry additional transit riders. Local bus service is the most cost effective approach to provide transit service over a wide area, and relates most directly to meeting the needs of the transit dependant.

Express Bus. Express bus service largely operates independently of local bus service and therefore, because it is independent, investments in express bus service captures a high portion of new transit riders. It is focused on moving commuters in high demand corridors. The operating costs for an express bus trip are higher than a local bus trip. This option relates most directly to relieving congestion.

Light Rail. Light rail service is located in the current highest demand local bus corridors. Therefore, substantial numbers of light rail passengers could be drawn from local bus service. In theory as corridor demands grow it will be more cost effective to serve high demand transit volumes with large rail vehicles rather than small buses. A more detailed corridor level of analysis is warranted to review further the relative cost effectiveness of rail versus expanded bus options, including bus rapid transit.

A major advantage of light rail is its potential as an economic development tool for central business districts. It has a positive image and can be located close to demand. Parking costs increase the competitive edge for transit in activity centers. The permanent nature of light rail investments demonstrates a public commitment to an area. Also, LRT can support special events when peak demands are high.

Shuttles. Shuttle service has low costs and low ridership. In the context of this regional system analysis costs per passenger mile are high, and much more detailed analysis is required. The shuttle services in this option primarily functions as a means to feed rail and express bus service in activity cores.

6.5 Summary

A fixed guideway and express bus concept with improved local bus service is recommended for further study. The concept includes a 39-mile light rail transit (LRT) system with enhanced express bus service in corridors not served by rail. Expanded shuttle service is also suggested to extend the patronage area for rail and express bus service in activity cores. A tripling of local bus service is the principal element of the regional long range transit plan. A tripling of Dial-a-Ride service would also be maintained as part of the regional plan.

A variety of related transit planning studies are currently underway and other studies are required. It is suggested that the recommended fixed guideway and express bus concept serve as a point of departure in updating the MAG Long Range Transit Plan.

APPENDIX A
Underserved Corridor Segment Demand

Table A-1
Indexed Demand and Underserved Demand By Corridor Segment

CORRIDOR NUMBER	SCREENLINE NUMBER	LOCATION: Btwn...	And...	V/C (1)	V/C (2)	V/C (3)	V/C (max)	ADT (1) (x1000)	ADT (2) (x1000)	ADT (3) (x1000)	ADPT (sum)	Corridor Capacity	Unserved Volume	Volume Catagory	Demand/Volume Index	Index Catagory	Unsrvd Vol/Vol Ratio
1	1	Lower Buckeye	Broadway	0.6528	0.8304		0.8304	28	85		158200	191000	0	3	0.417	3	
	2	Thomas	Indian School	0.8858			0.8858	36			50400	57000	0	1	0.133	1	
	3	Bethany Home	Glendale	1.1806			1.1806	31			43400	37000	10000	1	0.243	2	0.23
	4	Olive	Peoria	0.817			0.817	30			42000	51000	0	1	0.111	1	
	5	Greenway	Bell	0.6472			0.6472	27			37800	58000	0	1	0.100	1	
2	1	Broadway	Lower Buckeye	0.6459	0.3205		0.6459	21	6		37800	59000	0	1	0.100	1	
	2	Buckeye	N. Buren	0.8105	0.7133	0.6432	0.8105	26	107	20	214200	264000	0	4	0.565	3	
	3	McDowell	Thomas	0.8151	0.8807	1.222	1.222	29	31	151	295400	242000	78000	4	1.779	4	0.32
	4	Indian School	Camelback	1.0076	1.0898	0.8765	1.0898	37	11	33	113400	104000	20000	3	0.555	3	0.19
	5	Glendale	Northern	0.8505	0.9423	0.8628	0.9423	31	9	35	105000	111000	5000	3	0.341	3	0.05
	6	Greenway	Bell	0.9873			0.9873	12			16800	17000	1000	1	0.057	1	0.06
3	1	Broadway	Lower Buckeye	0.7788	0.7694	0.7709	0.7788	25	25	24	103600	133000	0	3	0.273	2	
	2	Buckeye	N. Buren	0.7926	0.8013	0.824	0.824	42	43	39	173600	211000	0	3	0.458	3	
	3	Thomas	Indian School	0.8149	0.904	0.8188	0.904	44	76	42	226800	251000	1000	4	0.611	4	0.00
	4	Glendale	Northern	0.8845	0.9528	0.8375	0.9528	41	38	43	170800	179000	9000	3	0.566	3	0.05
	5	Bell	Union Hills	0.6788	0.6094		0.6788	22	30		72800	107000	0	2	0.192	2	
4	1	Warner	Elliot	n/a*			0	n/a*			0		n/a*	1		1	
	2	Southern	Broadway	0.5899	0.6207		0.6207	20	20		56000	90000	0	2	0.148	1	
	3	Buckeye	N. Buren	0.8209	0.7556	0.6844	0.8209	111	30	31	240800	293000	0	4	0.635	4	
	4	Thomas	Indian School	0.8429	1.1267	0.8878	1.1267	143	38	37	305200	271000	61000	4	1.586	4	0.23
	5	Glendale	Northern	0.9188	0.8858		0.9188	155	38		270200	294000	6000	4	0.789	4	0.02
	6	Thunderbird	Greenway	0.7047	0.7868		0.7868	24	25		68600	87000	0	2	0.181	1	
5	1	Ray	Warner	0.6888	1.0445		1.0445	36	93		180600	173000	25000	3	0.797	4	0.14
	2	Southern	Broadway	1.0113	0.8771		1.0113	44	153		275800	273000	30000	4	1.112	4	0.11
	3	University	Brown	0.6495			0.6495	75			105000	162000	0	3	0.277	2	
	4	Airport Access	McDowell	0.2876	0.7601		0.7601	33	81		159600	210000	0	3	0.421	3	
	5	McDowell	Thomas	0.9214	0.8584		0.9214	17	29		64400	70000	1000	2	0.183	2	0.01
	6	Indian Bend	Olive	1.0422			1.0422	36			50400	48000	7000	1	0.223	2	0.15
	7	Greenway	Greenway	0.7217			0.7217	36			50400	70000	0	1	0.133	1	
6	1	Ray	Warner	0.7785			0.7785	30			42000	54000	0	1	0.111	1	
	2	Southern	Broadway	0.737			0.737	36			50400	68000	0	1	0.133	1	
	3	University	Brown	0.813			0.813	42			58800	72000	0	2	0.155	1	
	4	McDowell	Thomas	1.0028	1.022	1.0422	1.0422	44	8	8	84000	81000	11000	2	0.362	3	0.13
	5	Indian Bend	McDonald	1.0875	0.8836		1.0875	44	8		72800	67000	13000	2	0.359	3	0.19
	6	Greenway	Bell	0.5372			0.5372	26			36400	68000	0	1	0.096	1	
7	1	Warner	Elliot	0.7534			0.7534	24			33600	45000	0	1	0.089	1	
	2	Southern	Broadway	0.2999	0.7011	0.5778	0.7011	2	6	36	61600	88000	0	2	0.162	1	
	3	Brown	McKellips	0.2886	0.4457	0.5748	0.5748	15	6	6	37800	66000	0	1	0.100	1	
8	1	Warner	Elliot	0.6916			0.6916	33			46200	67000	0	1	0.122	1	
	2	Southern	Broadway	0.7325			0.7325	34			47600	65000	0	1	0.125	1	
	3	Brown	McKellips	0.7227			0.7227	26			36400	50000	0	1	0.096	1	
	4	Thomas	Shea	0.7018			0.7018	24			33600	48000	0	1	0.089	1	

Table A-1
Indexed Demand and Underserved Demand By Corridor Segment

9	1	Thomas	Indian School	1.322			1.322	36			50400	38000	16000	1	0.338	3	0.42
	2	Bethany Home	Glendale	1.0404			1.0404	34			47600	46000	6000	1	0.202	2	0.13
	3	Olive	Peoria	0.9409			0.9409	44			61600	65000	3000	2	0.201	2	0.05
10	1	Gilbert	Copper	0.9127	0.8279		0.9127	45	10		77000	84000	1000	2	0.216	2	0.01
	2	Hayden	Scottsdale	0.7254	0.7067		0.7254	24	35		82600	114000	0	2	0.218	2	
	3	56th	64th	0.6894	0.7805		0.7805	22	38		84000	108000	0	2	0.221	2	
	4	Tatum	40th	0.805	0.8572		0.8572	38	42		112000	131000	0	3	0.295	3	
	5	24th	32nd	0.8933			0.8933	46			64400	72000	0	2	0.170	1	
	6	18th	27th	0.9474	0.8706		0.9474	20	25		63000	66000	3000	2	0.205	2	0.05
	7	51st	43rd	0.788	0.8652		0.8652	31	36		93800	108000	0	2	0.247	2	
	8	67th	75th	0.7229	0.7982		0.7982	24	26		70000	88000	0	2	0.185	2	
11	1	Price	McClintock	0.6655	0.6073		0.6655	18	31		68600	103000	0	2	0.181	1	
	2	Kyrene	Priest	0.8557			0.8557	30			42000	49000	0	1	0.111	1	
	3	24th	32nd	0.8866	0.7603		0.8866	45	8		74200	84000	0	2	0.196	2	
	4	7th	16th	1.1032	1.0718	1.0524	1.1032	20	48	45	158200	143000	29000	3	0.789	4	0.20
	5	19th	7th	0.9965	0.9788		0.9965	51	48		138600	139000	13000	3	0.532	3	0.09
	6	35th	27th	1.0713			1.0713	39			54600	51000	9000	1	0.259	2	0.16
	7	59th	51st	0.9792			0.9792	36			50400	51000	4000	1	0.184	2	0.08
	8	75th	91st	0.7678			0.7678	33			46200	60000	0	1	0.122	1	
	9	115th	107th	0.5425			0.5425	18			25200	46000	0	1	0.066	1	
12	1	Greenfield	Val Vista	0.4142	0.6225		0.6225	22	15		51800	83000	0	1	0.137	1	
	2	Copper	McQueen	0.7359	0.9367		0.9367	81	39		168000	179000	7000	3	0.533	3	0.04
	3	Arizona	Alma School	1.0758	0.9626	0.8234	1.0758	33	88	30	211400	197000	35000	4	1.006	4	0.18
	4	Price	McClintock	0.9499	0.6617		0.9499	34	29		88200	93000	5000	2	0.297	3	0.05
	5	Kyrene	Priest	0.7764	0.7333		0.7764	25	37		86800	112000	0	2	0.229	2	
	6	32nd	24th	0.8594	1.0673	0.8725	1.0673	37	42	114	270200	253000	42000	4	1.251	4	0.17
	7	16th	7th	0.9994	0.8902	0.8966	0.9994	50	191	30	379400	380000	38000	4	1.487	4	0.10
	8	7th	19th	0.7477	1.1069	0.8486	1.1069	36	137	37	294000	266000	55000	4	1.480	4	0.21
	9	35th	43rd	1.1324	1.0423	0.9155	1.1324	41	37	140	305200	270000	63000	4	1.612	4	0.23
	10	75th	91st	0.6587	0.9652	0.6894	0.9652	33	22	124	250600	260000	17000	4	0.878	4	0.07
13	1	Greenfield	Val Vista	0.6641	0.6408	0.6702	0.6702	22	32	22	106400	159000	0	3	0.280	2	
	2	Gilbert	Copper	0.6888	0.7251	0.5823	0.7251	30	24	22	106400	147000	0	3	0.280	2	
	3	Dobson	Price	0.6178	0.7986	0.8155	0.8155	36	37	41	159600	196000	0	3	0.421	3	
	4	Price	McClintock	0.7169	0.7026	0.7026	0.7169	36	35	35	148400	207000	0	3	0.391	3	
	5	Kyrene	Priest	1.0146	0.8554		1.0146	44	34		109200	108000	12000	3	0.442	3	0.11
	6	40th	32nd	0.6699	1.0909		1.0909	170	30		280000	257000	49000	4	1.366	4	0.19
	7	7th	16th	1.0407	0.4885		1.0407	139	29		235200	226000	32000	4	1.030	4	0.14
	8	7th	19th	0.9244	0.4875		0.9244	124	27		211400	229000	6000	4	0.634	4	0.03
	9	43rd	51st	0.8688	0.8034		0.8688	28	26		75600	87000	0	2	0.199	2	
	10	67th	75th	0.871	0.821		0.871	29	29		81200	93000	0	2	0.214	2	
14	1	Recker	Higley	0.3545	0.794	0.5592	0.794	101	18	19	193200	243000	0	4	0.509	3	
	2	Gilbert	Copper	0.6178	0.8656	1.0355	1.0355	31	117	18	232400	224000	30000	4	0.997	4	0.13
	3	McQueen	Arizona	0.7288	1.0472	0.6259	1.0472	32	37	125	271600	259000	38000	4	1.203	4	0.15
	4	Price	McClintock	0.5971	1.1417	0.7294	1.1417	129	30	37	274400	240000	58000	4	1.467	4	0.21
	5	Kyrene	Priest	0.8438	0.8728	0.61	0.8728	152	40	24	302400	346000	0	4	0.797	4	

Table A-1
Indexed Demand and Underserved Demand By Corridor Segment

	6	40th	32nd	0.7149	0.6941		0.7149	29	34		88200	123000	0	2	0.232	2	
	7	16th	7th	0.7677	0.7828		0.7828	30	27		79800	102000	0	2	0.210	2	
	8	7th	19th	0.7173	0.7032		0.7173	24	25		68600	96000	0	2	0.181	1	
	9	35th	43rd	0.5814	0.5353		0.5814	21	19		56000	96000	0	2	0.148	1	
	1	Lindsay	Gilbert	0.3882	0.6564		0.6564	7	57		89600	137000	0	2	0.236	2	
	2	Gilbert	Copper	0.3067	0.7283		0.7283	16	69		119000	163000	0	3	0.314	3	
15	3	Alma School	Arizona	0.5562	0.8601		0.8601	27	82		152600	177000	0	3	0.402	3	
	4	Price	McClintock	0.8838			0.8838	77			107800	122000	0	3	0.284	3	
	5	Kyrene	Priest	0.8682			0.8682	68			95200	110000	0	2	0.251	2	
	1	Ray	Warner	0.8263	0.55		0.8263	121	4		175000	212000	0	3	0.461	3	
	2	Southern	Broadway	0.8183	1.095		1.095	21	110		183400	167000	33000	4	0.906	4	0.18
16	3	Brown	McKellips	0.9649			0.9649	122			170800	177000	11000	3	0.591	3	0.06
	4	Thomas	Indian School	0.6857	1.0202		1.0202	24	129		214200	210000	25000	4	0.885	4	0.12
	5	McDonald	Indian Bend	0.8338	0.962		0.962	128	28		218400	227000	14000	4	0.755	4	0.06
	6	Cactus	Thunderbird	0.8585	0.5405		0.8585	123	6		180600	210000	0	3	0.476	3	
	1	64th	56th	0.8846			0.8846	115			161000	182000	0	3	0.424	3	
	2	Tatum	40th	0.8831			0.8831	128			179200	203000	0	3	0.472	3	
17	3	24th	16th	0.9475	0.773		0.9475	125	12		191800	202000	10000	4	0.634	4	0.05
	4	7th	19th	0.9618	0.1135		0.9618	130	2		184800	192000	12000	4	0.641	4	0.06
	5	43rd	51st	0.3302	0.9914		0.9914	133	5		193200	195000	18000	4	0.740	4	0.09
	1	Buckeye	McKellips	0.5905			0.5905	20			28000	47000	0	1	0.074	1	
18	2	Thomas	Indian School	0.4373	0.954		0.954	122	13		189000	198000	11000	4	0.639	4	0.06
	3	Glendale	Northern	0.7813	0.4589		0.7813	102	19		169400	217000	0	3	0.446	3	
	4	Greenway	Bell	0.8046	0.3428		0.8046	80	26		148400	184000	0	3	0.391	3	
											379400		78000				
												max volume:	379400	max index:	1.779	max dmnd ratio:	0.421
												75th %ile:	182000	75th %ile:	0.606	75th %ile:	0.179
												50th %ile:	103600	50th %ile:	0.284	50th %ile:	0.111
												25th %ile:	56000	25th %ile:	0.183	25th %ile:	0.055
												min volume:	0	min index:	0.057	min dmnd ratio:	0.004

APPENDIX B

Fixed Guideway System Options – 2020 Annualized Costs

PLAN OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	7,866	1,441	47	0	0	n.a.	n.a.	9,354
2	Off-Peak Hour Revenue Miles/a	7,537	0	30	0	0	n.a.	n.a.	7,567
3	Miles of Rail	0	0	0	0	0	n.a.	n.a.	0
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	1	0	0	0	n.a.	n.a.	1
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	$30,000.0	$10,000.0	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mile/k	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile/l	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$30,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	40,124,364	2,893,528	191,216	0	0	16,522,995	0	59,732,103
42	Total Vehicles/q	1,352	81	8	0	0	691	0	2,132
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$432,701.14	$32,291.77	$1,644.46	$0.00	$0.00	$31,079.75	$0.00	$497,717.13
44	Rail/s	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
45	Minor Passenger Facilities/t	$116,761.90	$8,420.17	$556.44	$0.00	$0.00	$0.00	$0.00	$125,738.50
46	Major Passenger Facilities/t2	$0.00	$142,250.00	$0.00	$0.00	$0.00	$0.00	$0.00	$142,250.00
47	Maintenance Facilities/u	$94,533.00	$6,817.15	$450.50	$0.00	$0.00	$38,928.18	$0.00	$140,728.83
48	Other Capital /v	$22,389.40	$1,614.59	$106.70	$0.00	$0.00	$9,219.83	$0.00	$33,330.51
49	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
50	Subtotal of Replacement Costs	$666,385.44	$191,393.68	$2,758.10	$0.00	$0.00	$79,227.76	$0.00	$939,764.98
	REVENUE								
50.1	Total Fares/ae	$36,012	$3,566	$172	$0	$0	$2,706	$0	$42,456
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$108,034.85	$11,323.82	$514.85	$0.00	$0.00	$26,208.77	$0.00	$146,082.29
52	Support Operations/x	$24,877.11	$1,793.99	$118.55	$0.00	$0.00	$10,244.26	$0.00	$37,033.90
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$132,911.96	$13,117.81	$633.40	$0.00	$0.00	$36,453.03	$8,500.00	$191,616.20
	CAPITAL								
55	Vehicles/y	$54,477.93	$4,065.60	$234.13	$0.00	$0.00	$9,175.62	n.a.	$67,953.28
56	Rail/z	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
57	Passenger Facilities/aa	$14,700.56	$24,882.40	$70.06	$0.00	$0.00	$0.00	$0.00	$39,653.02
58	Maintenance Facilities/ab	$13,459.37	$970.61	$64.14	$0.00	$0.00	$5,542.50	$0.00	$20,036.62
59	Other Capital Costs/ac	$5,460.57	$393.78	$26.02	$0.00	$0.00	$2,248.63	$0.00	$8,129.00
60	Grand Ave Busway Costs/ad	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Subtotal	$88,098.43	$30,312.40	$394.36	$0.00	$0.00	$16,966.74	$0.00	$135,771.92
	TOTAL	$221,010.38	$43,430.20	$1,027.76	$0.00	$0.00	$53,419.78	$8,500.00	$327,388.12

a. Traffic Model Assignment: 2020BLD WLIGHT RAIL & EXPRESS BUS

b. Includes cost of commuter bus service to outlying communities.

b2. Includes cost of related roadway improvements in express bus/busway option.

c. 251 days per year, 8 hours per day

d. 251 days per year, 7 hours per day

e. 251 days per year, 4 hours per day

f. 104 weekend days plus 10 holidays per year, 17 hours per day

g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.

g2. Calculated using 1998 fleet size and vehicle revenue miles.

h. Includes rail line, stations and vehicles.

k. Includes transit centers, bus benches, bus shelters and bus pullouts.

l. Includes maintenance facilities, LNG facilities, and shop equipment.

m. Includes office equipment, bus communication system, bus AVL system, passenger information system, computer facilities, office space and support vehicles.

n. From MAG System Study Cost Sheet for Express Bus/Busway Option. Presented to TRC on XXX.

p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.

q. Row 41 * Row 27 / 1,000,000.

r. Row 42 * Row 28

s. Row 29 * Row 3.

t. Row 41 * Row 30.

t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).

u. Row 41 * Row 31.

v. Row 41 * Row 32.

w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.

x. Row 41 * Row 26.

y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.

z. Row 44 discounted at 7% using a life span of 25 yrs.

aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.

ab. Row 47 discounted at 7% using a life span of 10 yrs.

ac. Row 48 discounted at 7% using a life span of 5 yrs.

ad. Row 49 discounted at 7% using a life span of 30 yrs.

ae. Row 25 * Row 41 * Row 36

EXPRESS BUS/BUSWAY OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	7,872	7,751	569	0	0	n.a.	n.a.	16,192
2	Off-Peak Hour Revenue Miles/a	7,543	0	0	0	0	n.a.	n.a.	7,543
3	Miles of Rail	0	0	0	0	0	n.a.	n.a.	0
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	22	0	0	0	n.a.	n.a.	22
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	n.a.	$920,000.00	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	$30,000.0	$10,000.0	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mile/k	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile/l	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$27,045.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	40,155,780	15,564,008	1,142,552	0	0	16,522,995	0	73,385,335
42	Total Vehicles/q	1,353	434	49	0	0	691	0	2,527
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$433,039.93	$173,694.33	$9,825.95	$0.00	$0.00	$31,079.75	n.a.	$647,639.96
44	Rail/s	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$0.00
45	Minor Passenger Facilities/t	$116,853.32	$45,291.26	$3,324.83	$0.00	$0.00	n.a.	n.a.	$165,469.41
46	Major Passenger Facilities/t2	$0.00	$707,250.00	$0.00	$0.00	$0.00	$0.00	n.a.	$707,250.00
47	Maintenance Facilities/u	$94,607.02	$36,668.80	$2,691.85	$0.00	$0.00	$38,928.18	n.a.	$172,895.85
48	Other Capital /v	$22,406.93	$8,684.72	$637.54	$0.00	$0.00	$9,219.83	n.a.	$40,949.02
49	Road Improvements/b2	n.a.	$920,000.00	n.a.	n.a.	n.a.	n.a.	n.a.	$920,000.00
50	Subtotal of Replacement Costs	$666,907.19	$1,891,589.11	$16,480.17	$0.00	$0.00	$79,227.76	$0.00	$2,654,204.24
	REVENUE								
50.1	Total Fares/ae	$36,040	$19,183	$1,025	$0	$0	$2,706	$0	$58,954
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$108,119.44	$58,172.92	$3,076.32	$0.00	$0.00	$26,208.77	$0.00	$195,577.45
52	Support Operations/x	$24,896.58	$9,649.68	$708.38	$0.00	$0.00	$10,244.26	$0.00	$45,498.91
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$133,016.02	$67,822.60	$3,784.70	$0.00	$0.00	$36,453.03	$8,500.00	$249,576.36
	CAPITAL								
55	Vehicles/y	$54,520.59	$21,868.46	$1,398.99	$0.00	$0.00	$9,175.62	n.a.	$86,963.66
56	Rail/z	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
57	Passenger Facilities/aa	$14,712.07	$124,143.84	$418.60	$0.00	$0.00	$0.00	$0.00	$139,274.50
58	Maintenance Facilities/ab	$13,469.91	$5,220.81	$383.26	$0.00	$0.00	$5,542.50	$0.00	$24,616.48
59	Other Capital Costs/ac	$5,464.84	$2,118.12	$155.49	$0.00	$0.00	$2,248.63	$0.00	$9,987.08
60	Grand Ave Busway/HOV System Costs/ad	$0.00	$74,139.49	$0.00	$0.00	$0.00	$0.00	$0.00	$74,139.49
61	Subtotal	$88,167.41	$227,490.72	$2,356.35	$0.00	$0.00	$16,966.74	$0.00	$334,981.22
	TOTAL	$221,183.43	$295,313.33	$6,141.05	$0.00	$0.00	$53,419.78	$8,500.00	$584,557.58

a. Traffic Model Assignment: 2020BLD WLIGHT RAIL & EXPRESS BUS
b. Includes cost of commuter bus service to outlying communities.
b2. Includes cost of related roadway improvements in express bus/busway option.
HOV Connections between the Pima and the Red Mountain and between the Price and the Santan; grade separations north of the Agua Fria Freeway.
c. 251 days per year, 8 hours per day
d. 251 days per year, 7 hours per day
e. 251 days per year, 4 hours per day
f. 104 weekend days plus 10 holidays per year, 17 hours per day
g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.
g2. Calculated using 1998 fleet size and vehicle revenue miles.
h. Includes rail line, stations and vehicles.
k. Includes transit centers, bus benches, bus shelters and bus pullouts.
l. Includes maintenance facilities, LNG facilities, and shop equipment.
m. Includes office equipment, bus communication system, bus AVL system, passenger information system, computer facilities, office space and support vehicles.
n. From MAG System Study Cost Sheet for Express Bus/Busway Option. Presented to TRC on XXX.
p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.
q. Row 41 * Row 27 / 1,000,000.
r. Row 42 * Row 28
s. Row 29 * Row 3.
t. Row 41 * Row 30.
t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).
u. Row 41 * Row 31.
v. Row 41 * Row 32.
w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.
x. Row 41 * Row 26.
y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.
z. Row 44 discounted at 7% using a life span of 25 yrs.
aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.
ab. Row 47 discounted at 7% using a life span of 10 yrs.
ac. Row 48 discounted at 7% using a life span of 5 yrs.
ad. Row 49 discounted at 7% using a life span of 30 yrs.
ae. Row 25 * Row 41 * Row 36

COMMUTER RAIL OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	**8,081**	**1,006**	**385**	**0**	**495**	n.a.	n.a.	9,967
2	Off-Peak Hour Revenue Miles/a	**7,747**	**0**	**0**	**0**	**0**	n.a.	n.a.	7,747
3	Miles of Rail	**0**	**0**	**0**	**0**	**96**	n.a.	n.a.	96
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	1	0	0	0	n.a.	n.a.	1
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	$30,000.0	**18,750**	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mil	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$30,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	41,233,964	2,020,048	773,080	0	993,960	16,522,995	0	61,544,047
42	Total Vehicles/q	1,390	56	33	0	0	691	0	2,170
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$444,667.07	$22,543.74	$6,648.49	$0.00	$0.00	$31,079.75	$0.00	$504,939.05
44	Rail/s	$0.00	$0.00	$0.00	$0.00	$1,800,000.00	$0.00	$0.00	$1,800,000.00
45	Minor Passenger Facilities/t	$119,990.84	$5,878.34	$2,249.66	$0.00	$0.00	$0.00	$0.00	$128,118.84
46	Major Passenger Facilities/t2	$0.00	$142,250.00	$0.00	$0.00	$0.00	$0.00	$0.00	$142,250.00
47	Maintenance Facilities/u	$97,147.22	$4,759.23	$1,821.38	$0.00	$0.00	$38,928.18	$0.00	$142,656.00
48	Other Capital /v	$23,008.55	$1,127.19	$431.38	$0.00	$0.00	$9,219.83	$0.00	$33,786.95
49	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
50	Subtotal of Replacement Costs	$684,813.67	$176,558.50	$11,150.91	$0.00	$1,800,000.00	$79,227.76	$0.00	$2,751,750.84
	REVENUE								
50.1	Total Fares/ae	$37,007	$2,490	$694	$0	$4,028	$2,706	$0	$46,925
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$111,022.45	$8,094.13	$2,081.52	$0.00	$6,041.29	$26,208.77	$0.00	$153,448.16
52	Support Operations/x	$25,565.06	$1,252.43	$479.31	$0.00	$0.00	$10,244.26	$0.00	$37,541.05
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$136,587.51	$9,346.56	$2,560.83	$0.00	$6,041.29	$36,453.03	$8,500.00	$199,489.21
	CAPITAL								
55	Vehicles/y	$55,984.47	$2,838.30	$946.60	$0.00	$0.00	$9,175.62	n.a.	$68,944.98
56	Rail/z	$0.00	$0.00	$0.00	$0.00	$154,458.93	$0.00	$0.00	$154,458.93
57	Passenger Facilities/aa	$15,107.08	$24,562.38	$283.24	$0.00	$0.00	$0.00	$0.00	$39,952.71
58	Maintenance Facilities/ab	$13,831.58	$677.61	$259.32	$0.00	$0.00	$5,542.50	$0.00	$20,311.01
59	Other Capital Costs/ac	$5,611.57	$274.91	$105.21	$0.00	$0.00	$2,248.63	$0.00	$8,240.32
60	Grand Ave Busway Costs/ad	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Subtotal	$90,534.70	$28,353.20	$1,594.36	$0.00	$154,458.93	$16,966.74	$0.00	$291,907.95
	TOTAL	$227,122.21	$37,699.76	$4,155.19	$0.00	$160,500.22	$53,419.78	$8,500.00	$491,397.16

a. Traffic Model Assignment: 2020BLD WLIGHT RAIL & EXPRESS BUS
b. Includes cost of commuter bus service to outlying communities.
b2. Includes cost of related roadway improvements in express bus/busway option.
c. 251 days per year, 8 hours per day
d. 251 days per year, 7 hours per day
e. 251 days per year, 4 hours per day
f. 104 weekend days plus 10 holidays per year, 17 hours per day
g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.
g2. Calculated using 1998 fleet size and vehicle revenue miles.
h. Includes rail line, stations and vehicles.
k. Includes transit centers, bus benches, bus shelters and bus pullouts.
l. Includes maintenance facilities, LNG facilities, and shop equipment.
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n. From MAG System Study Cost Sheet for Express Bus/Busway Option. Presented to TRC on XXX.
p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.
q. Row 41 * Row 27 / 1,000,000.
r. Row 42 * Row 28
s. Row 29 * Row 3.
t. Row 41 * Row 30.
t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).
u. Row 41 * Row 31.
v. Row 41 * Row 32.
w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.
x. Row 41 * Row 26.
y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.
z. Row 44 discounted at 7% using a life span of 25 yrs.
aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.
ab. Row 47 discounted at 7% using a life span of 10 yrs.
ac. Row 48 discounted at 7% using a life span of 5 yrs.
ad. Row 49 discounted at 7% using a life span of 30 yrs.
ae. Row 25 * Row 41 * Row 36

AT-GRADE LIGHT RAIL OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	7,835	628	327	991	0	n.a.	n.a.	9,781
2	Off-Peak Hour Revenue Miles/a	7,533	0	163	496	0	n.a.	n.a.	8,192
3	Miles of Rail	0	0	0	68	0	n.a.	n.a.	68
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	1	0	0	0	n.a.	n.a.	1
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	$30,000.0	$10,000.0	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mil	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$30,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	40,049,204	1,261,024	1,182,780	3,591,016	0	16,522,995	0	62,607,019
42	Total Vehicles/q	1,350	35	51	0	0	691	0	2,126
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$431,890.62	$14,073.03	$10,171.91	$0.00	$0.00	$31,079.75	$0.00	$487,215.31
44	Rail/s	$0.00	$0.00	$0.00	$2,040,000.00	$0.00	$0.00	$0.00	$2,040,000.00
45	Minor Passenger Facilities/t	$116,543.18	$3,669.58	$3,441.89	$0.00	$0.00	$0.00	$0.00	$123,654.65
46	Major Passenger Facilities/t2	$0.00	$142,250.00	$0.00	$0.00	$0.00	$0.00	$0.00	$142,250.00
47	Maintenance Facilities/u	$94,355.92	$2,970.97	$2,786.63	$0.00	$0.00	$38,928.18	$0.00	$139,041.70
48	Other Capital /v	$22,347.46	$703.65	$659.99	$0.00	$0.00	$9,219.83	$0.00	$32,930.93
49	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
50	Subtotal of Replacement Costs	$665,137.18	$163,667.23	$17,060.42	$2,040,000.00	$0.00	$79,227.76	$0.00	$2,965,092.59
	REVENUE								
50.1	Total Fares/ae	$35,944	$1,554	$1,062	$15,901	$0	$2,706	$0	$57,167
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$107,832.48	$5,287.64	$3,184.64	$23,851.53	$0.00	$26,208.77	$0.00	$166,365.06
52	Support Operations/x	$24,830.51	$781.83	$733.32	$0.00	$0.00	$10,244.26	$0.00	$36,589.92
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$132,662.99	$6,069.47	$3,917.96	$23,851.53	$0.00	$36,453.03	$8,500.00	$211,454.98
	CAPITAL								
55	Vehicles/y	$54,375.89	$1,771.82	$1,448.25	$0.00	$0.00	$9,175.62	n.a.	$66,771.58
56	Rail/z	$0.00	$0.00	$0.00	$175,053.46	$0.00	$0.00	$0.00	$175,053.46
57	Passenger Facilities/aa	$14,673.02	$24,284.30	$433.34	$0.00	$0.00	$0.00	$0.00	$39,390.66
58	Maintenance Facilities/ab	$13,434.16	$423.00	$396.75	$0.00	$0.00	$5,542.50	$0.00	$19,796.41
59	Other Capital Costs/ac	$5,450.34	$171.61	$160.97	$0.00	$0.00	$2,248.63	$0.00	$8,031.55
60	Grand Ave Busway Costs/ad	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Subtotal	$87,933.40	$26,650.73	$2,439.31	$175,053.46	$0.00	$16,966.74	$0.00	$309,043.65
	TOTAL	$220,596.39	$32,720.20	$6,357.27	$198,904.98	$0.00	$53,419.78	$8,500.00	$520,498.62

a. Traffic Model Assignment: 2020BLD WLIGHT RAIL & EXPRESS BUS

b. Includes cost of commuter bus service to outlying communities.

b2. Includes cost of related roadway improvements in express bus/busway option.

c. 251 days per year, 8 hours per day

d. 251 days per year, 7 hours per day

e. 251 days per year, 4 hours per day

f. 104 weekend days plus 10 holidays per year, 17 hours per day

g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.

g2. Calculated using 1998 fleet size and vehicle revenue miles.

h. Includes rail line, stations and vehicles.

k. Includes transit centers, bus benches, bus shelters and bus pullouts.

l. Includes maintenance facilities, LNG facilities, and shop equipment.

m. Includes office equipment, bus communication system, bus AVL system, passenger information system, computer facilities, office space and support vehicles.

n. From MAG System Study Cost Sheet for Express Bus/Busway Option. Presented to TRC on XXX.

p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.

q. Row 41 * Row 27 / 1,000,000.

r. Row 42 * Row 28

s. Row 29 * Row 3.

t. Row 41 * Row 30.

t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).

u. Row 41 * Row 31.

v. Row 41 * Row 32.

w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.

x. Row 41 * Row 26.

y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.

z. Row 44 discounted at 7% using a life span of 25 yrs.

aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.

ab. Row 47 discounted at 7% using a life span of 10 yrs.

ac. Row 48 discounted at 7% using a life span of 5 yrs.

ad. Row 49 discounted at 7% using a life span of 30 yrs.

ae. Row 25 * Row 41 * Row 36

AUTOMATED RAIL OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	**7,665**	**787**	**283**	**720**	**0**	n.a.	n.a.	9,455
2	Off-Peak Hour Revenue Miles/a	**7,533**	**0**	**156**	**360**	**0**	n.a.	n.a.	8,049
3	Miles of Rail	**0**	**0**	**0**	**31**	**0**	n.a.	n.a.	31
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	1	0	0	0	n.a.	n.a.	1
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	**70,000**	$10,000.0	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mile/k	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile/l	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$30,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	39,707,844	1,580,296	1,071,832	2,607,840	0	16,522,995	0	61,490,807
42	Total Vehicles/q	1,338	44	46	0	0	691	0	2,119
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$428,209.39	$17,636.10	$9,217.76	$0.00	$0.00	$31,079.75	$0.00	$486,143.00
44	Rail/s	$0.00	$0.00	$0.00	$2,170,000.00	$0.00	$0.00	$0.00	$2,170,000.00
45	Minor Passenger Facilities/t	$115,549.83	$4,598.66	$3,119.03	$0.00	$0.00	$0.00	$0.00	$123,267.52
46	Major Passenger Facilities/t2	$0.00	$142,250.00	$0.00	$0.00	$0.00	$0.00	$0.00	$142,250.00
47	Maintenance Facilities/u	$93,551.68	$3,723.18	$2,525.24	$0.00	$0.00	$38,928.18	$0.00	$138,728.27
48	Other Capital /v	$22,156.98	$881.81	$598.08	$0.00	$0.00	$9,219.83	$0.00	$32,856.70
49	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
50	Subtotal of Replacement Costs	$659,467.87	$169,089.75	$15,460.10	$2,170,000.00	$0.00	$79,227.76	$0.00	$3,093,245.49
	REVENUE								
50.1	Total Fares/ae	$35,638	$1,948	$962	$11,548	$0	$2,706	$0	$52,801
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$106,913.37	$6,468.14	$2,885.91	$17,321.27	$0.00	$26,208.77	$0.00	$159,797.47
52	Support Operations/x	$24,618.86	$979.78	$664.54	$0.00	$0.00	$10,244.26	$0.00	$36,507.44
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$131,532.23	$7,447.93	$3,550.44	$17,321.27	$0.00	$36,453.03	$8,500.00	$204,804.91
	CAPITAL								
55	Vehicles/y	$53,912.41	$2,220.42	$1,312.40	$0.00	$0.00	$9,175.62	n.a.	$66,620.85
56	Rail/z	$0.00	$0.00	$0.00	$186,208.82	$0.00	$0.00	$0.00	$186,208.82
57	Passenger Facilities/aa	$14,547.95	$24,401.27	$392.69	$0.00	$0.00	$0.00	$0.00	$39,341.91
58	Maintenance Facilities/ab	$13,319.65	$530.10	$359.54	$0.00	$0.00	$5,542.50	$0.00	$19,751.78
59	Other Capital Costs/ac	$5,403.88	$215.06	$145.87	$0.00	$0.00	$2,248.63	$0.00	$8,013.44
60	Grand Ave Busway Costs/ad	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Subtotal	$87,183.90	$27,366.85	$2,210.50	$186,208.82	$0.00	$16,966.74	$0.00	$319,936.82
	TOTAL	$218,716.13	$34,814.78	$5,760.94	$203,530.10	$0.00	$53,419.78	$8,500.00	$524,741.73

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b2. Includes cost of related roadway improvements in express bus/busway option.
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g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.
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k. Includes transit centers, bus benches, bus shelters and bus pullouts.
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n. From MAG System Study Cost Sheet for Express Bus/Busway Option. Presented to TRC on XXX.
p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.
q. Row 41 * Row 27 / 1,000,000.
r. Row 42 * Row 28
s. Row 29 * Row 3.
t. Row 41 * Row 30.
t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).
u. Row 41 * Row 31.
v. Row 41 * Row 32.
w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.
x. Row 41 * Row 26.
y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.
z. Row 44 discounted at 7% using a life span of 25 yrs.
aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.
ab. Row 47 discounted at 7% using a life span of 10 yrs.
ac. Row 48 discounted at 7% using a life span of 5 yrs.
ad. Row 49 discounted at 7% using a life span of 30 yrs.
ae. Row 25 * Row 41 * Row 36

LIGHT RAIL/COMMUTER RAIL OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	7,835	597	311	906	195	n.a.	n.a.	9,844
2	Off-Peak Hour Revenue Miles/a	7,533	0	155	453	0	n.a.	n.a.	8,141
3	Miles of Rail	0	0	0	62	52	n.a.	n.a.	113
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	1	0	0	0	n.a.	n.a.	1
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	$30,000.0	$10,000.0	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mile/k	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile/l	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$30,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	40,049,204	1,198,776	1,124,828	3,281,532	391,560	16,522,995	0	62,568,895
42	Total Vehicles/q	1,350	33	48	0	0	691	0	2,122
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$431,890.62	$13,378.34	$9,673.52	$0.00	$0.00	$31,079.75	$0.00	$486,022.23
44	Rail/s	$0.00	$0.00	$0.00	$1,845,000.00	$515,000.00	$0.00	$0.00	$2,360,000.00
45	Minor Passenger Facilities/t	$116,543.18	$3,488.44	$3,273.25	$0.00	$0.00	$0.00	$0.00	$123,304.87
46	Major Passenger Facilities/t2	$0.00	$142,250.00	$0.00	$0.00	$0.00	$0.00	$0.00	$142,250.00
47	Maintenance Facilities/u	$94,355.92	$2,824.32	$2,650.09	$0.00	$0.00	$38,928.18	$0.00	$138,758.51
48	Other Capital /v	$22,347.46	$668.92	$627.65	$0.00	$0.00	$9,219.83	$0.00	$32,863.86
49	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
50	Subtotal of Replacement Costs	$665,137.18	$162,610.01	$16,224.52	$1,845,000.00	$515,000.00	$79,227.76	$0.00	$3,283,199.47
	REVENUE								
50.1	Total Fares/ae	$35,944	$1,477	$1,010	$14,531	$1,587	$2,706	$0	$57,255
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$107,832.48	$5,057.47	$3,028.60	$21,795.94	$2,379.90	$26,208.77	$0.00	$166,303.17
52	Support Operations/x	$24,830.51	$743.24	$697.39	$0.00	$0.00	$10,244.26	$0.00	$36,515.40
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$132,662.99	$5,800.72	$3,725.99	$21,795.94	$2,379.90	$36,453.03	$8,500.00	$211,318.57
	CAPITAL								
55	Vehicles/y	$54,375.89	$1,684.36	$1,377.29	$0.00	$0.00	$9,175.62	n.a.	$66,613.16
56	Rail/z	$0.00	$0.00	$0.00	$158,320.40	$44,192.42	$0.00	$0.00	$202,512.82
57	Passenger Facilities/aa	$14,673.02	$24,261.49	$412.11	$0.00	$0.00	$0.00	$0.00	$39,346.62
58	Maintenance Facilities/ab	$13,434.16	$402.12	$377.31	$0.00	$0.00	$5,542.50	$0.00	$19,756.09
59	Other Capital Costs/ac	$5,450.34	$163.14	$153.08	$0.00	$0.00	$2,248.63	$0.00	$8,015.19
60	Grand Ave Busway Costs/ad	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Subtotal	$87,933.40	$26,511.11	$2,319.79	$158,320.40	$44,192.42	$16,966.74	$0.00	$336,243.87
	TOTAL	$220,596.39	$32,311.83	$6,045.79	$180,116.34	$46,572.32	$53,419.78	$8,500.00	$547,562.44

a. Traffic Model Assignment: 2020BLD WLIGHT RAIL & EXPRESS BUS

b. Includes cost of commuter bus service to outlying communities.

b2. Includes cost of related roadway improvements in express bus/busway option.

c. 251 days per year, 8 hours per day

d. 251 days per year, 7 hours per day

e. 251 days per year, 4 hours per day

f. 104 weekend days plus 10 holidays per year, 17 hours per day

g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.

g2. Calculated using 1998 fleet size and vehicle revenue miles.

h. Includes rail line, stations and vehicles.

k. Includes transit centers, bus benches, bus shelters and bus pullouts.

l. Includes maintenance facilities, LNG facilities, and shop equipment.

m. Includes office equipment, bus communication system, bus AVL system, passenger information system, computer facilities, office space and support vehicles.

n. From MAG System Study Cost Sheet for Express Bus/Busway Option. Presented to TRC on XXX.

p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.

q. Row 41 * Row 27 / 1,000,000.

r. Row 42 * Row 28

s. Row 29 * Row 3.

t. Row 41 * Row 30.

t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).

u. Row 41 * Row 31.

v. Row 41 * Row 32.

w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.

x. Row 41 * Row 26.

y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.

z. Row 44 discounted at 7% using a life span of 25 yrs.

aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.

ab. Row 47 discounted at 7% using a life span of 10 yrs.

ac. Row 48 discounted at 7% using a life span of 5 yrs.

ad. Row 49 discounted at 7% using a life span of 30 yrs.

ae. Row 25 * Row 41 * Row 36

LIGHT RAIL AND EXPRESS BUS OPTION 2020 ANNUALIZED COSTS

(In Thousands of 1998 Dollars)

		Local Bus	Express Bus	Shuttles	Light Rail	Commuter Rail	Dial-a-Ride	TDM/Special	Total
	INPUT (PLAN)								
1	Peak Hour Revenue Miles/a	7,700	2,021	423	648	0	n.a.	n.a.	10,792
2	Off-Peak Hour Revenue Miles/a	7,443	0	227	324	0	n.a.	n.a.	7,994
3	Miles of Rail	0	0	0	39	0	n.a.	n.a.	39
4	No. of Express Park-and-Rides	0	30	0	0	0	n.a.	n.a.	30
5	No. of On-Line Express Stations	0	4	0	0	0	n.a.	n.a.	4
6	Deck Park Station	0	1	0	0	0	n.a.	n.a.	1
7	Annual Revenue Miles of Dial-a-Ride	n.a.	n.a.	n.a.	n.a.	n.a.	16,522,995	n.a.	16,522,995
8	Cost of TDM and Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
9	Other Operating Costs/b	$0.00	$625.00	$0.00	$0.00	$0.00	$0.00	$0.00	$625.00
10	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	CONSTANTS								
	REVENUE MILES								
21	Ann. Peak Hours of Service/c	2,008	2,008	2,008	2,008	2,008	n.a.	n.a.	n.a.
22	Ann. Off-Peak Hours of Service/d	1,757	0	1,757	1,757	1,757	n.a.	n.a.	n.a.
23	Ann. Late Evening Hours of Service/e	1,004	1,004	1,004	1,004	1,004	n.a.	n.a.	n.a.
24	Ann. Weekend and Holiday Hours of Service/f	1,938	1,938	1,938	1,938	1,938	n.a.	n.a.	n.a.
	OPERATIONS								
25	Vehicle Operating Cost per Annual Revenue Mile	$0.00359	$0.00493	$0.00359	$0.01107	$0.01013	$0.00175	n.a.	n.a.
26	Support Operating Cost per Revenue Mile/g	$0.00062	$0.00062	$0.00062	n.a.	n.a.	$0.00062	n.a.	n.a.
	CAPITAL								
27	Vehicles per Million Ann. Revenue Miles/g2	33.7	27.9	43.0	n.a.	n.a.	41.8	n.a.	n.a.
28	Vehicle Unit Cost	$320.0	$400.0	$200.0	n.a.	n.a.	$45.0	n.a.	n.a.
29	Rail Cost per Mile/h	n.a.	n.a.	n.a.	$30,000.0	$10,000.0	n.a.	n.a.	n.a.
30	Minor Passenger Fac. Costs per Ann. Revenue Mile/k	$0.00291	$0.00291	$0.00291	n.a.	n.a.	n.a.	n.a.	n.a.
31	Maintenance Facility Costs per Ann. Revenue Mile/l	$0.00236	$0.00236	$0.00236	n.a.	n.a.	$0.00236	n.a.	n.a.
32	Other Minor Capital Costs/m	$0.00056	$0.00056	$0.00056	n.a.	n.a.	$0.00056	n.a.	n.a.
33	Park-and-Ride Lot Cost	n.a.	$3,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
34	On-Line Station Cost/n	n.a.	$30,000.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
35	Deck Park Station Replacement Cost	n.a.	$22,250.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	REVENUE								
36	Fare Recovery Ratio	0.25	0.25	0.25	0.4	0.4	0.0936	n.a.	n.a.
	INTERMEDIATE CALCULATIONS								
	MISCELLANEOUS								
41	Total Annual Revenue Miles/p	39,487,604	4,058,168	1,582,140	2,347,056	0	16,522,995	0	63,997,963
42	Total Vehicles/q	1,331	113	68	0	0	691	0	2,203
	REPLACEMENT COST IN 2020								
43	Vehicle/r	$425,834.32	$45,289.15	$13,606.40	$0.00	$0.00	$31,079.75	$0.00	$515,809.63
44	Rail/s	$0.00	$0.00	$0.00	$1,170,000.00	$0.00	$0.00	$0.00	$1,170,000.00
45	Minor Passenger Facilities/t	$114,908.93	$11,809.27	$4,604.03	$0.00	$0.00	$0.00	$0.00	$131,322.22
46	Major Passenger Facilities/t2	$0.00	$232,250.00	$0.00	$0.00	$0.00	$0.00	$0.00	$232,250.00
47	Maintenance Facilities/u	$93,032.80	$9,561.04	$3,727.52	$0.00	$0.00	$38,928.18	$0.00	$145,249.54
48	Other Minor Capital /v	$22,034.08	$2,264.46	$882.83	$0.00	$0.00	$9,219.83	$0.00	$34,401.21
49	Road Improvements/b2	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
50	Subtotal of Replacement Costs	$655,810.13	$301,173.93	$22,820.79	$1,170,000.00	$0.00	$79,227.76	$0.00	$2,229,032.60
	REVENUE								
50.1	Total Fares/ae	$35,440	$5,002	$1,420	$10,393	$0	$2,706	$0	$54,961
	OUTPUT (2020 ANNUALIZED COST)								
	OPERATIONS								
51	Vehicle Operations (net of fares)/w	$106,320.37	$15,630.08	$4,259.91	$15,589.15	$0.00	$26,208.77	$0.00	$168,008.28
52	Support Operations/x	$24,482.31	$2,516.06	$980.93	$0.00	$0.00	$10,244.26	$0.00	$38,223.56
53	TDM/Special Needs	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	$8,500.00	$8,500.00
54	Subtotal	$130,802.69	$18,146.14	$5,240.84	$15,589.15	$0.00	$36,453.03	$8,500.00	$214,731.84
	CAPITAL								
55	Vehicles/y	$53,613.39	$5,701.99	$1,937.25	$0.00	$0.00	$9,175.62	n.a.	$70,428.25
56	Rail/z	$0.00	$0.00	$0.00	$100,398.31	$0.00	$0.00	$0.00	$100,398.31
57	Passenger Facilities/aa	$14,467.26	$40,381.20	$579.66	$0.00	$0.00	$0.00	$0.00	$55,428.12
58	Maintenance Facilities/ab	$13,245.78	$1,361.28	$530.72	$0.00	$0.00	$5,542.50	$0.00	$20,680.27
59	Other Minor Costs/ac	$5,373.91	$552.28	$215.32	$0.00	$0.00	$2,248.63	$0.00	$8,390.13
60	Other Major Costs/ad	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
61	Subtotal	$86,700.34	$47,996.75	$3,262.93	$100,398.31	$0.00	$16,966.74	$0.00	$255,325.07
	TOTAL	$217,503.02	$66,142.89	$8,503.77	$115,987.45	$0.00	$53,419.78	$8,500.00	$470,056.91

a. Traffic Model Assignment: 2020BLD WLIGHT RAIL & EXPRESS BUS

b. Includes cost of commuter bus service to outlying communities.

b2. Includes cost of related roadway improvements in express bus/busway option.

c. 251 days per year, 8 hours per day

d. 251 days per year, 7 hours per day

e. 251 days per year, 4 hours per day

f. 104 weekend days plus 10 holidays per year, 17 hours per day

g. Includes general administration, regional customer service, facility maintenance, security, support vehicle operations.

g2. Calculated using 1998 fleet size and vehicle revenue miles.

h. Includes rail line, stations and vehicles.

k. Includes transit centers, bus benches, bus shelters and bus pullouts.

l. Includes maintenance facilities, LNG facilities, and shop equipment.

m. Includes office equipment, bus communication system, bus AVL system, passenger information system, computer facilities, office space and support vehicles.

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p. (Row 1 * Row 21) + (Rw 2 * Row 22) + (Row 2 * Row 23 * 0.5) + (Row 2 * Row 24 * 0.5); for dial-a-ride use Row 7.

q. Row 41 * Row 27 / 1,000,000.

r. Row 42 * Row 28

s. Row 29 * Row 3.

t. Row 41 * Row 30.

t2. (Row 4 * Row 33)+(Row 5* Row 34)+(Row 6 * Row 35).

u. Row 41 * Row 31.

v. Row 41 * Row 32.

w. Row 41 * Row 25 * (1 - Row 36). For express add Row 9.

x. Row 41 * Row 26.

y. Row 43 discounted using a life span of 12 years for local and express buses, 10 years for shuttles and 4 years for Dial-a-Ride.

z. Row 44 discounted at 7% using a life span of 25 yrs.

aa. Row 45 and Row 46 discounted at 7% using a life spans of 11 yrs for major replacements and 8 yrs for minor replacements.

ab. Row 47 discounted at 7% using a life span of 10 yrs.

ac. Row 48 discounted at 7% using a life span of 5 yrs.

ad. Row 49 discounted at 7% using a life span of 30 yrs.

ae. Row 25 * Row 41 * Row 36

APPENDIX C
Financial Model

DESCRIPTION OF FINANCIAL AND ECONOMIC EVALUATION MODEL

OVERVIEW

In order to address cost and funding aspects of the MAG Fixed Guideway Study, a two-part financial model was developed. The first element, termed the "master model," includes detailed breakdowns and revenue projects by fiscal year from 1999 through 2020. This model was used to develop the funding plan for the recommended modal option. The results of this model are included in Table 6.1.

The second model element is a "sketch planning" model. It utilizes greatly simplified cost estimates and other input data to generate 2020 annualized replacement cost estimates for all eight alternatives reviewed in this study. The sketch planning model yields estimates for one year only (2020), and does not address funding issues. The results of applying this model to each of the eight are shown in Appendix B.

DESCRIPTION – MASTER MODEL

The master model is a large spreadsheet, containing the components shown in **Figure C-1** on the following page. Operating characteristics are the principal input, along with capital needs per revenue mile of service and unit cost factors. These data are combined to develop capital and operating cost estimates.

Other model inputs include annual revenue estimates from proposed funding sources, and various assumptions needed to address debt-financing (bonding) options. The bottom line of the spreadsheet is a simulation of future annual cashflow, including total income, expenses, and net balance (carryforward). The model is utilized through an iterative process in which revenues and expenditures are adjusted until funding balances are within an acceptable range.

Key Input and intermediate factors addressed in the master model include:

Operating Data

- Daily hours of service, by mode, time of day, and day of week;
- Annual service hours (clock hours in service, not cumulative vehicle hours), by mode;
- Hourly and annual revenue service miles, by mode and time of day;
- Average annual revenue miles per vehicle, by mode/vehicle type;

Life Cycle and System Management Data

- Useful economic life, by vehicle and facility type/function;
- Vehicle retirements and acquisitions, by mode and year;
- System management facilities and equipment needs;

FIGURE C-1

FIXED GUIDEWAY STUDY FINANCIAL ANALYSIS
MASTER MODEL – PRINCIPAL ELEMENTS

Element	Function
COSTS	
System Operating Policies (For all fixed guideway and bus modes)	**INPUT**
System Physical Quantities (Facilities, vehicles, etc.)	**INPUT**
Unit Costs (For capital outlay and operations)	**INPUT**
System Operating Characteristics (Service hours, vehicle revenue miles, etc.)	**INTERMEDIATE OUTPUT**
Cumulative System Costs (For capital outlay and system O&M expenses)	**INTERMEDIATE OUTPUT**
FUNDING	
Funding Scenario (Assumptions regarding federal funds, fares, sales taxes, etc.)	**INPUT**
Debt Financing Market Assumptions (Bond term, coupon rate, issuance cost, etc.)	**INPUT**
Revenue Yield (By source and year)	**INTERMEDIATE OUTPUT**
Debt Financing Needs and Costs (Bond sizes, timing, and debt service)	**INTERMEDIATE OUTPUT**
CASHFLOW	
Annual Cashflow (Revenues and expenditures)	**FINAL OUTPUT**
Ending Balance (Cash carryforward)	**FINAL OUTPUT**

Capital Investment Requirements

- New and upgraded facility needs, by mode and facility type and year;
- Upgrade/rehabilitation intervals, by facility type;
- Light rail construction (miles), by year and location;

Unit Cost Data

- Unit capital cost, by facility or equipment type and mode;
- Vehicle acquisition cost, by vehicle type;
- System operating cost per revenue service mile, by mode;
- System management and miscellaneous administrative costs per revenue service mile, by mode;

Calculated Costs

- Calculated capital outlay requirements, by mode, function, and year;
- Calculated operations and maintenance expenses, by mode, function, and year;

Revenue and Funding Yields

- Assumed revenue yield by funding source and year;
- Debt financing assumptions;
- Farebox recovery policies;
- Net revenue yield after bond sales and debt service;

Data and estimating procedures were drawn from a number of sources, including MAG transportation modeling output, City of Phoenix and RPTA operations data, assumptions and findings from the Central Phoenix - East Valley Major Investment Study, and Federal Transit Administration and other transit industry sources.

DESCRIPTION – SKETCH PLANNING MODEL

The second element of the financial analysis system, a sketch-planning model designed to convert simplified cost and operations planning data into estimates of 2020 annualized cost and cost-effectiveness, is depicted in **Figure C-2,** below. Principal inputs to the model are:

- Projected revenue-miles by mode;
- Physical facilities and other key quantities; and
- Key operating and capital unit costs.

Intermediate sketch-planning model calculations include:

- Total annual revenue miles;
- Total vehicles;
- Total system replacement costs (all elements); and
- Fare revenue.

Based on these inputs and intermediate results, year 2020 annualized system costs – including annual capital recovery requirements ("replacement costs") and operating expenses net of fares – are calculated by mode and service element and then summed for each of the nine alternatives. Cost-effectiveness – annualized cost per transit rider – is then determined, both on an absolute basis and, for each of the alternatives, relative to the Current Plan.

FIGURE C-2

FIXED GUIDEWAY FINANCIAL ANALYSIS
SKETCH PLANNING MODEL – PRINCIPAL ELEMENTS

ALL ITEMS COMPUTED FOR ALL ALTERNATIVES[1]

Element	Function
Physical Quantities (Stations, vehicles, miles of guideway, etc.)	**INPUT**
Operations Policies and Unit Costs (Costs per revenue-mile; costs for special services, etc.)	**INPUT**
Operating Characteristics (Revenue-miles by mode; Vehicle requirements)	**INTERMEDIATE CALCULATION**
Replacement Costs in 2020 (Facilities, Equipment, and Infrastructure)	**INTERMEDIATE CALCULATION**
2020 Annualized Cost ("Replacement Cost" annuity based on straight line depreciation)	**INTERMEDIATE OUTPUT**
Cost-Effectiveness 1 (Annualized replacement cost plus 2020 net operating cost per transit rider)	**FINAL OUTPUT**
Cost-Effectiveness 2[1] (Net annualized cost per new transit rider – relative to the "Plan" Alternative)	**FINAL OUTPUT**

1. Cost-Effectiveness 2 not calculated for "No Build" and "Plan" Alternatives.

MODEL RESULTS

Costs, Revenues, and Cashflow (Master Model)

Selected key intermediate and final results from the Master Financial Analysis Model are summarized in **Figure C-3**, on the following page.

2020 Annualized Costs and Cost-Effectiveness (Sketch-Planning Model)

Selected key intermediate and final results from the Financial Analysis Sketch-Planning Model are summarized in **Figure C-4,** on the following page.

REVIEW OF MODEL STRUCTURE, ASSUMPTIONS, AND RESULTS

Prior to publication of the draft final report, a review of materials depicting estimated costs, revenues, cashflow, annualized cost, and cost-effectiveness was performed in order to confirm the reliability of the findings and identify areas for potential future enhancement. Most important among the general findings of the review were:

- Overall, the financial analysis appears to be very thorough in scope, addressing all important issues relating to financial feasibility and economic efficiency at a level of detail appropriate to a regional "system-level" study; and

- The analysis more than adequately demonstrates the basic financial feasibility of the proposed long-range transit program, as the cost and revenue estimates are, with only limited exception, well within the ranges and tolerances of results typically found in studies of this type.

With respect to the "2020 Annualized Cost & Cost-effectiveness " figures as shown in Figure C-4, it should be noted that these were calculated for each modal element of each alternative based on "useful life," "annualization factors" and "discount rate" assumptions developed by the Federal Transit Administration for use in federal Major Investment Studies. Note that this calculation is not a true annualized cost – that is, an annuity equivalent to the total net present value of all cash flows occurring throughout the project analysis period (e.g., 20 years) – but rather is a "snapshot" estimate of the sum total of one year's depreciation (straight line) of all fixed assets contained within a given alternative system, plus nominal cost of capital (the "discount rate").

While this approach represents an appropriate level of detail for a systemwide study, it also should be noted that the same results will be obtained regardless of the actual scheduling of expenditures and income over the 20-year period, provided that the 20-year totals remain constant. The calculations, therefore, do not portray the relative strengths and weakness of the alternatives with regard to the timing of benefits and costs, and therefore are not annualizations of total 20-year system economic cost in today's terms, but are better described as "annualized replacement costs" for mature systems (essentially, sinking fund annuities), plus one year's operating income and expenses.

It is also important to note that ridership figures will change as models are updated and as more detailed analysis is undertaken at the corridor level.

FIGURE C-3

FIXED GUIDEWAY FINANCIAL ANALYSIS
MASTER MODEL –
SELECTED INTERMEDIATE AND FINAL RESULTS

LIGHT RAIL & EXPRESS BUS ALTERNATIVE

Item	Value
2020 Revenue Service Miles (Millions; NOT Cumulative)	
· Local Bus	37.8
· Express Bus	3.9
· Shuttle Bus	1.6
· Light Rail	2.3
Physical Facilities Added (Cumulative to 2020)	
· Miles of Light Rail	39
· Transit Centers	6
· Park-and-Ride Lots	30
· Express Bus Stations (Incl. Central Ave. Deck)	5
· Bus Benches	1,669
· Bus Shelters	1,852
· Maintenance Facilities	4
· LNG Stations	6
Bus Vehicles Purchased (Cumulative to 2020)	
· Local Buses	1,878
· Express Buses	208
· Shuttle Buses	340
· Dial-a-Ride Buses	2,376
New Facilities Costs (Cum. To 2020; $1998 in Mils.)	
· Light Rail (Including Vehicles)	$1,170.0
· Transit Centers	$22.3
· Park-and-Ride Lots	$84.0
· Express Bus Stations (Incl. Central Ave. Deck)	$54.3
· Bus Benches	$2.8
· Bus Shelters	$22.7
· Maintenance Facilities	$69.6
· LNG Stations	$18.2
Bus Vehicle Costs (Cum. To 2020; $1998 in Mils.)	
· Local Buses	$601.0
· Express Buses	$83.2
· Shuttle Buses	$68.0
· Dial-a-Ride Buses	$106.9

FIGURE C-3 (continued)

FIXED GUIDEWAY FINANCIAL ANALYSIS
MASTER MODEL –
SELECTED INTERMEDIATE AND FINAL RESULTS

LIGHT RAIL & EXPRESS BUS ALTERNATIVE

Item	Value
Other Capital Costs (Cum. to 2020; $1998 in Mils.)	
· Passenger Facility Upgrade Costs	$34.5
· Maintenance Facilities (New and Upgraded)	$143.5
· System Management & Bus Pullouts	$60.1
Operations and Maintenance Expenses (Cum. to 2020; $1998 in Mils.)	$2,417.8
· Local Bus Operations	$262.3
· Express Bus Operations	$85.0
· Shuttle Bus Operations	$454.6
· Dial-a-Ride Operations	$293.6
· Light Rail Operations	$839.6
· Special Services, Administration, and Other Expenses	
Net Revenue Yield (Cum. to 2020; $1998 in Mils.)	
· Regional and Local Funds (Exc. Sales Taxes)	$726.2
· Federal Grants	$1,230.8
· Fares	$870.6
· Sales Taxes (Net after Debt Service)	$4,157.8

FIGURE C-4

FIXED GUIDEWAY FINANCIAL ANALYSIS
SKETCH PLANNING MODEL –
SELECTED INTERMEDIATE AND FINAL RESULTS

Alternative	Annualized Cost ($1998 in Mil.)	Cost-Effectiveness (All Riders)
1. No Build	$118.4	$4.41
2. Current 2020 Plan	$306.2	$5.59
3. Light Rail	$520.5	$8.38
4. Commuter Rail	$491.4	$8.38
5. Automated Guideway	$524.7	$9.30
6. Express Bus/Busway	$584.6	$8.03
7. Commuter Rail/Light Rail	$547.6	$8.97
8. Light Rail/Express Bus	**$470.1**	**$7.41**

1. Calculated using net costs and ridership relative to the "Current Plan" Alternative.

Cost-effectiveness was calculated for each alternative in two ways, as follows:

(1) Total Net Annualized Cost ÷ Total Annual Ridership
(2) Total Incremental Net Annualized Cost ÷ Total Incremental Annual Ridership

where the second calculation is net relative to baseline condition: Alternative 2 (Current 2020 Plan).

It should be noted that only direct, public financial expenditures and income are considered in these calculations; all other public and private financial and non-financial costs and benefits are excluded.

A number of small modifications were suggested and implemented in the short term to clarify and otherwise improve the accuracy of the bottom-line results. In addition, however, at least four areas were identified in which more significant modifications and improvements could be made over the longer-term as part of future revisions to the regional plan, as well as during subsequent corridor-level project development studies. The four suggested enhancements were:

- Implement a more detailed system for capital and operations cost calculations, particularly with respect to light rail capital and O&M costs. More specifically, separate light rail vehicle capital costs from structures, facilities, and systems costs. Also, add explicit markup factors for "soft costs" – design, administration, construction management, and contingency.

- Consistent with a conclusion presented in Section 6.0 of the Study Report (System Elements/ Local Bus), develop a methodology for adding more refinement to the operational definitions of the modal systems (local bus, express bus, light rail, etc.) to address such issues as coverage versus frequency, intermodal transfer, nature of off-peak and non-weekday service, etc.

- Develop an ability within the cashflow simulation model to track fund flows by:

    (1) Funding source and application – mode, function (capital investment or recurring expenses), activity, timing, etc.; and

    (1) Location of funding and location of expenditure – regional equity by city and/or other subarea.

- Further, utilize the enhanced funding source/application model structure to optimize cashflow with the aim of reducing revenue requirements and/or enhancing transit service delivery.

Also it should be noted that ridership figures will change as models are updated and as more detailed analysis is undertaken at the corridor level.

APPENDIX D
CONCEPTUAL FUNDING PLAN

CONCEPTUAL FUNDING PLAN

PURPOSE

Under federal law governing the commitment of federal surface transportation funding assistance, all urban areas are required to maintain adequate long-range transportation plans, including the demonstration of ". . . existing and proposed funding sources that can reasonably be expected to be available." Further, federal regulations require that "proposed new revenue [sources] shall be identified, including strategies for ensuring their availability for proposed investments."

In order to facilitate the inclusion of the proposed fixed guideway transit concept (Light Rail Plus Express Bus Option) into the next update of the MAG Regional Transportation Plan, a conceptual funding plan for the proposed concept was developed, including "reasonably available" existing and proposed revenue sources. The funding concept described in this appendix includes a combination of existing and proposed new sources of funds, drawing on resources from all levels of government.

It should be noted that the funding plan described here is indeed conceptual in nature and, while it is appropriate for regional-level analysis, more extensive analysis and refinement will be necessary for project-level planning and implementation.

INCLUDED TRANSIT SERVICE

A detailed description of the service elements included in the proposed Light Rail Plus Express Bus concept can be found in Section 6.2 of the main report. The elements included are:

- Light Rail Transit - A 39-mile, at-grade system connecting and serving the downtown areas of Glendale, Phoenix, Tempe, and Mesa, with spurs to Metro Center and Rio Salado.

- Express Bus - The proposed element would more than double the current route mileage, and link major activity centers not served by the light rail system.

- Local Bus - Total local bus route mileage would more than double by 2010 and nearly triple by 2020. This element would also provide for upgrade and expansion of various existing facilities.

- Shuttles - The proposed concept would provide circulator service in downtown areas, certain major activity centers, and select high-traffic corridors not served by light rail.

- Dial-a-Ride - The proposed concept includes the current plan of doubling the current level of service by 2010 and tripling it by 2020.

- Related Programs - A portion of transit revenues are reserved for special programs such as welfare-to-work and demand management programs.

- Commuter Bus Service - Provides weekday peak-period bus service to all communities in Maricopa County.

FUNDING RESOURCE REQUIREMENTS

Capital and operations and maintenance cost data are presented in Chapter 5 for all alternatives studied, and are summarized for the preferred concept in Table 6.1. Over the 21-year analysis period (to 2020), estimated capital outlay for all service elements would total slightly more than $2.5 billion (in terms of constant 1998 dollars), while total operating expenditures for all services would be just shy of $4.0 billion. After adding bond interest expenses and various other "soft costs" of program development, the combined total systemwide capital and operating cost of the proposed fixed guideway transit concept (Light Rail Plus Express Bus Option) from the present to the year 2020 would total some $7.2 billion in constant 1998 dollars – an amount equivalent to the revenue yield from a 0.65% countywide sales tax over the same 21-year period.

SOURCES OF FUNDING

A variety of funding strategies could be developed to support the proposed transit concept, each involving some combination of funding from both "existing/committed" sources, and new sources judged to be "reasonably available." All potential funding sources, whether existing or new, can be classified according to the following hierarchy of control:

- Federal formula and discretionary grant programs;
- State discretionary transportation funds;
- Regional (countywide) dedicated revenue mechanism (sales tax or other);
- Local (city and county) dedicated revenue mechanisms (sales tax and/or other);
- Local (city and county) discretionary funds; and
- Private sector contributions.

Existing "Committed" Funding Sources and Amounts

As demonstrated in Table 6.1, the funding concept developed for the proposed transit option suggests that as much as 40 percent of the total funding need could be met from existing federal, state, and local sources. These sources are described, briefly, below.

Federal Funds

- Federal Section 5309 Discretionary Rail "New Start" and Bus Capital Funds - It is assumed, based on actual federal funding commitments made over the past decade, that the federal government will fund one-half (50 percent) of all capital outlay for both initial construction and for periodic reinvestment in vehicles, way and structures, and other equipment.

- Federal funds for bus purchases are assumed to continue at the current level of $5 million per year, plus another $10 million annually based on the recent pattern of Congressional earmarks.

- Federal Section 5307 Formula Transit Capital Funds - The current level of formula grant funding set by TEA-21 and the most recent round of appropriations is assumed to continue on a *current* dollar basis – that is, it will decline slightly over time on a constant dollar basis as the result of inflation. No federal operations and maintenance support through Section 5307 is assumed.

- MAG/Federal CMAQ Formula Funds - CMAQ funding for bus acquisition and TDM programs is assumed to continue at a constant level of $7.0 million per year.

- Federal Section 5310 Formula Funds (Paratransit) - These funds will be used to support the purchase of vans by nonprofit organizations.

State Funds

- Arizona Local Transportation Assistance Fund (LTAF) and Public Transportation Assistance (PTA) Fund - State support for transit will include continued distribution of the Local Transportation Assistance Fund (LTAF), with additional funding through the companion Public Transit Fund (PTF).

Local Funds

- City General Funds - Local support for bus capital and bus operations is provided principally through the City of Phoenix general fund and the City of Tempe cent dedicated transit sales tax. For this analysis, the City of Phoenix general fund contribution is held to its FY 1997-98 level of $22 million, not adjusted for inflation. No increase in the Tempe sales tax is contemplated.

- Public Transportation Fund (PTF) - Provided to the RPTA from a share of the current half-cent countywide sales tax, revenue from this source is assumed to end with the mandated cessation of that tax in 2005.

User Fees

- Transit Fares - Farebox recovery ratios of 25 percent for buses, 40 percent for light rail, and 9 percent for dial-a-ride services are assumed.

New "Reasonably Available" Funding Sources

With the estimated level of existing funding, the required contribution from new funding sources would be reduced to the equivalent of a 0.4% countywide tax. Additional local funding for both the bus system expansion and the LRT system could come from a variety of sources or mechanisms, such as a new sales tax within the City's of Phoenix and Mesa, and additional financing through bonding from the City of Tempe. Other potential funding sources could come from benefit assessment districts, property taxes, fuel taxes, state infrastructure banks, or vehicle licensing taxes. In Tempe, some revenue would also be derived from the elimination of duplicative bus service. Specific bus services that would be eliminated and revenue that could be transferred to LRT operations have not been identified at this time. However, while local funding mechanisms other than the sales tax are possible, and new contributions from other state sources such as the vehicle license tax (VLT) also are possible, the past several years of planning and policy actions at the regional and local level suggest that the sales tax is the mechanism with greatest level of public and official support. For the purposes of this funding concept, it is assumed that the required resources would be generated from some combination of new dedicated regional and local sales taxes.

Regional Sales Tax

For purposes of demonstrating revenue sufficiency in this funding concept, it was assumed that funding from a regional sales tax would be structured as according to current state statute – that is, one-half of a new 0.5% tax (0.25% or a quarter-cent) would be dedicated to transit needs, with the other half earmarked for highways. With authorization by MAG, RPTA, CTOC and Maricopa County and

approval by a simple majority of voters, the tax could be scheduled to begin and end at any time. For this analysis, it was assumed that the tax *election* would be held in 2000, but that collection of revenue would not commence until after termination of the current half-cent tax in 2005. The new tax would expire in 2020. "Zero-coupon" or similar revenue anticipation notes (short-term bonds) would be sold in the 2001-2005 period and repaid over the 2006-2020 period.

Local Sales Taxes

It was assumed that funding equivalent to the remaining 0.15% countywide tax not funded through existing sources or a new quarter-cent countywide tax would be generated through local (citywide) sales taxes collected by the four cities participating in the light rail program. Collection would begin sometime within the 2000-2005 time frame, and would continue until at least 2020.

As mentioned previously, revenue sources and mechanisms other than the sales tax are theoretically possible; however, the recent record of actions taken in support of sales tax initiatives by officials and the voting public strongly suggests that the sales tax is still the funding mechanism "of choice."

FUNDING STRATEGY

Federal guidelines on the proper way to demonstrate the "reasonable availability" of future funding offer two key suggestions:

1. Existing Sources – Funding from sources that are now available and have been available for some period of time may be extrapolated from past experience over the duration of the planning period.

2. New Sources – The funding plan should identify strategies for ensuring the availability of new funding, including a specific plan of action describing the steps needed to secure any necessary legislation, voter approvals, or multi-agency actions.

A review of all currently existing funding sources used in this funding concept shows that all such sources meet the tests of Item 1, immediately above. That is, of the sources listed on pages C-2 and C-3 (1) are currently available; (2) have been available for some period of time; and (3) are authorized for continued use for an indefinite period of time or have a history of periodic reauthorization are equal or higher funding levels (such as the federal surface transportation program).

Further, the projection of new sales tax revenue to fund the balance of cost not met from existing sources is based on an active history of sales tax initiatives (elections) in Maricopa County since 1985. While not all of these have succeeded, there is a clear and convincing pattern of official policy and voter support of the sales tax for transportation-related improvements. This past pattern, coupled with current active efforts to authorize new sales tax elections in the City of Phoenix and elsewhere, together more than meet the test for "reasonable availability" of new sources.